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Frank Scott Hogg
1904-1951

By JOHN F. HEARD

Dr. Frank Scott Hogg died suddenly of a heart ailment aggravated by bronchitis, at the age of forty-six, on New Year's Day at his home in Richmond Hill. He was Professor of Astronomy and Head of the Department at the University of Toronto, and also Director of the David Dunlap Observatory. One of Canada's leading astronomers, he was well known in the United States as well, having visited, at one time or other, most of the major American observatories.

Dr. Hogg was born in Preston, Ontario, not far from Toronto. Both his parents were University of Toronto graduates, his father having

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been a physician. He himself came to the University of Toronto in 1922, entering the Mathematics and Physics course with a scholarship. He graduated in 1926, winning the Gold Medal of the Royal Astronomical Society of Canada. For his graduate work he chose Harvard University, where he took his A.M. and Ph.D. At Harvard he held an Agassiz Fellowship, worked under the direction of Professor Harlow Shapley, and had the distinction of being the first Ph.D. graduate in astronomy at that University. The study of cometary spectra which he made at Harvard has remained a classic contribution to this field of research. During 1929-30 he was a Parker Travelling Fellow from Harvard and took the opportunity to visit most of the European observatories. After his return to the United States he visited the west coast observatories, spending some time at Lick and Mount Wilson.

In 1930, Dr. Hogg married a brilliant Radcliffe graduate in astronomy, Dr. Helen Sawyer, and accepted a teaching post in astronomy at Amherst College. The next year he was invited to return to Canada as Assistant Astronomer at the Dominion Astrophysical Observatory at Victoria. There he remained until 1934 when he came to the University of Toronto as Lecturer under his old teacher, Dr. C. A. Chant, Head of the Astronomy Department. During the following years he became assistant professor and then associate professor, and helped Dr. Chant and his successor, Dr. R. K. Young, organize the David Dunlap Observatory which was opened in 1935.

In succeeding years Dr. Hogg played an active part in the teaching of astronomy and in the observing programs of the Observatory. His major interest at that time lay in the radial velocity programs which have occupied most of the time with the 74-inch telescope. As the senior member of Dr. Young's staff, he took a large share in the observing, measuring, computing, and correlating of the data. During this time and in the years of Dr. Hogg's directorship the Observatory has accounted for about 15 per cent of the total accumulation of radial velocity data. The current velocity program, designed and supervised by Dr. Hogg and now nearing completion, embraces 1050 stars of late type in the 25° to 30° north declination band, the proper motions of which are known. At the same time Dr. Hogg took a keen interest in the other major observing program with the 74-inch, namely, Helen Sawyer Hogg's program of variables in globular clusters. For many years they shared the observing on these programs, he on the observing floor and Mrs. Hogg in the guiding position at the Newtonian focus.

During the war Dr. Hogg taught classes in Air Navigation, and invented a two-star sextant intended to simplify astronomical navigation. Working models of this instrument were constructed at the Observatory under government grants, and these were extensively tested by the Armed services of both Canada and the United States.

It was at the New Year in 1946 that, with the retirement of Dr. Young, Dr. Hogg became Head of the Department of Astronomy and

Director of the Observatory. His five years as Director were fruitful years for the Department and the Observatory. Many research programs came to completion under his active direction. Graduate students worked on such varied problems as spectrophotometry, binary stars, instrument design, and micrometeorites. The graduate work in astronomy was extended to include the Ph.D. degree; the first Ph.D. student is submitting a thesis this year on a problem completed under Dr. Hogg's direction.

One of Dr. Hogg's most recent interests was the problem of micrometeorites. He had long felt that a systematic approach to this problem was overdue. During 1947 and 1948 a graduate student, D. K. Norris, and he instituted a program of collection of airborne dust, and devised a technique for sorting out the magnetic constituents. As a result of collections made both locally and in Arctic stations as far north as 73 degrees latitude, they concluded that, whereas much of the magnetic material, especially in low latitudes, was a product of industrial smoke, certain types of metallic fragments fell with relative uniformity in different localities and contained a proportion of nickel which pointed to meteoritic origin. The program was extended the next year, and there still remain samples to be studied.

Dr. Hogg was well known as a writer on astronomical topics. Since 1937 he had been Assistant Editor of the *Journal of the Royal Astronomical Society of Canada* and of the *Observer's Handbook*. In recent years this took a substantial part of his time and effort. For about ten years he wrote a weekly astronomy feature, entitled "With the Stars," for the *Toronto Daily Star*, the circulation of which is 400,000. In addition he contributed to many other periodicals, professional and popular.

Dr. Hogg found time to take part in professional societies: in the Royal Astronomical Society of Canada, of which he was President in 1943-44; in the American Astronomical Society, to the Council of which he was recently nominated; in the Royal Canadian Institute, on the Council of which he served from 1946 till 1950; and in the International Astronomical Union, in which he was Chairman of the National Committee for Canada, and a member of three commissions. Dr. Hogg also found time to take a leading part in community life in Richmond Hill. He was a charter member and past President of the Lion's Club, and he served for the past two years as Chairman of the Richmond Hill High School Area Board.

Dr. Hogg leaves to mourn him his wife, Dr. Helen Sawyer Hogg, and three children, Sally, a second year student at the University of Toronto, and David and James at High School. Dr. Helen Hogg has been on the staff of the Observatory and the Department of Astronomy ever since her husband came to the University, and is well known for her own research and writing in astronomy. She plans to remain at the University.

Canadian astronomy has lost a great deal in the death of Dr. Frank

Hogg; the University has lost a great scholar; his colleagues and his many friends have lost a wonderfully, unselfish and generous helper and companion.

David Dunlap Observatory, Richmond Hill, Ontario.

Long-Focus Photographic Astrometry

By PETER VAN DE KAMP

(Continued from page 137)

CHAPTER IV

Parallax and Proper Motion

1. *At the telescope and measuring machine.*

In the first decade of the twentieth century Frank Schlesinger developed the current long-focus procedure for photographic parallax determinations.[1,2,3] Schlesinger's investigations were made with the Yerkes refractor of 19.4 meters focal length; his technique and reduction methods are basic and complete, and only minor improvements have remained possible.

We mentioned the stringent hour-angle requirements. At the Sproul Observatory, photographs are rarely taken more than one hour off the meridian. A recent survey of 30 parallax determinations, involving some 3000 plates, reveals little range in the average hour-angle at different times of the night; the algebraic average is within one minute of time of the meridian.[4] The maximum systematic difference in hour-angle, comparing dawn and dusk observations, amounts to less than 20 minutes. The corresponding differential dispersion effect in right ascension is less than ″.0012 for an extreme difference in spectrum, A to M, (Chapter I). This material therefore is systematically well compensated for dispersion effects.

In order to obtain a satisfactory set of reference stars, the exposure times are often several minutes long. Guiding is necessary and is accomplished by using a double-slide plate carrier, permitting an accurate slow motion of the plate holder. A guide-star is kept centered on the cross wires of a small eyepiece attached to the plate carrier; the observer bears the greater part of the responsibility for accurate guiding of the telescope necessary to obtain good photographic records. Even so, some guiding error is unavoidable and its effect depends in the first place on the brightness of the star. Magnitude compensation between parallax and reference stars is usually obtained by reducing the brightness of the central star by means of a rotating sector in front of the plate, or a grating may be used. Sector openings smaller than about 2.5% (extinction 4 magnitudes) lead to a slight increase in error, and generally should be avoided. If greater magnitude reduction is required,

a neutral filter in addition to the rotating sector may be successfully used.

Besides equalizing the magnitude of the central star with the average magnitude of the reference stars, it is desirable to have a small dispersion in the magnitudes of the reference stars. No magnitude error need generally be feared if both the compensation between central star and reference stars and the dispersion in the magnitudes of the reference stars are below half a magnitude. Since guiding error occurs mostly in the direction of diurnal motion, a slight elongation of the exposures in the direction of right ascension is well-nigh unavoidable; this is not a serious matter as long as the elongation is not asymmetrical.

At the Sproul Observatory, plates of 5 x 7 inches (13 x 18 cm) are taken in the focal plane of the 24-inch refractor. (See also Chapter I.) Each plate contains from one to four exposures; plate weights are assigned, depending on quality and number of exposures, according to the following schedule:[5]

	No. of exposures			
Quality	4	3	2	1
good	1.4	1.2	1.0	.7
fair	1.2	1.0	.7	.5
poor	1.0	.7	.5	.3

The plates are measured on a long-screw engine (Chapter I), with the film turned toward the microscope objective. Two successive settings are made on each image; the central star is usually measured twice. The plates are measured in 4 positions differing by 90° each, representing the "direct" and "reversed" directions of right ascension and declination; the average of the direct and reversed values in each coordinate are thus reasonably free from systematic errors of bisection, varying with the measurer and the intensity of the photographic image.

Experience has shown that the positional accuracy is hardly dependent on the seeing, provided inferior definition is avoided. This is in part due to the extent of the reference frame, which causes a lack of coherence between the formation of the exposures for central and reference stars; emulsion shifts also play a role. Apart from such obvious qualities as symmetry, the most important requirement for high positional accuracy is that the exposures shall be well blackened, *i.e.*, give a good representation of the position of the star; the sharpness of the image is of secondary importance.

2. *Plate, night, and measurement errors. Double plates. Night weight.*

Increase in positional accuracy on any one night may be obtained by increasing the number of exposures per plate, and the number of plates. The former is limited by the extent of the reference frame, and by the *plate errors*, common to all exposures on one and the same plate. Generally, therefore, no more than three or four exposures per single plate are taken. Plate errors are to a great extent due to emulsion shifts,

which are of course most serious for their full effect on the central star. These film shifts amount occasionally to as much as 10 microns or more. They may be somewhat reduced by special treatment of the plates; for example, the "normalizing" process has been found quite effective.[6,7] In this method stresses in undeveloped gelatine emulsion are relieved before exposure by soaking the plates in water, followed by dehydration in alcohol. The process is, however, cumbersome and it has not found general application in the problems discussed at present.

Another, simple procedure has been found effective and has been adopted for the Sproul long-focus astrometric work. Appreciable reduction of film errors is obtained by the use of "double plates," obtained by turning the same photographic plate 180° in its own plane between the two successive sets of exposures, representing the two "single plates." This procedure is an application of the general principle of eliminating systematic errors by reversal. The two sets of exposures for the central star are close together on the emulsion; here the effects of a general film shift are virtually equal and opposite for the two successive single plates. The effectiveness of the double-plate procedure in reducing the effect of film shifts on the measured position of the central star has been established from studies by Dr. Gustav Land;[8,9,10] only film errors of a minor accidental nature remain, which are added to the accidental plate errors explained by random refraction oscillations, the formation of the photographic image, and the measuring machine. The double-plate procedure is especially desirable for larger configurations where this source of error is to a great extent responsible for the decreased positional accuracy of single sets of exposures. Further reduction in film errors, through the use of a small configuration of reference stars is often not practical because of large proper motion of the central star or of the lack of appropriate reference stars.

The number of plates on any one night is limited by the *night errors*, which are probably due to refraction anomalies. These positional night errors are assumed constant during all the exposures of one and the same field within the same night. For the Sproul Observatory Dr. Land finds an average value of $\pm$".0124 (probable error) for the night error, while the average accidental plate error, which includes film, image, and measurement errors, amounts to $\pm$ ".0274 (p.e.) when reduced to unit weight.[9] Plate error and night error combine into an error of $\pm$ ".030 (p.e.) for one plate of unit weight. This value therefore represents the accuracy obtained from one good plate with two exposures, for the position of the central star relative to the background of reference stars.

The law of diminishing returns, as enforced by the night errors, makes it advisable to introduce a *night weight* (p). For example, total plate weights of 5 and 10, at Sproul are reduced to effective night weights of only 3 and 4 because of the existence of night errors. A total plate weight of 5 therefore yields an error $\pm$ ".017 (p.e.), while a total plate weight of 10 reduces the error no further than $\pm$ ".015 (p.e.).

Hence, whenever exposure times are sufficiently short, two double plates, but no more, are taken; the single component plates have three or four exposures each. In this way a night weight of three is obtained; more material for any one night is generally not warranted.[11]

Often it will be desirable to obtain a very high accuracy, for example, in studying the systematic behaviour of residuals from a solution for parallax and proper motion, which may represent orbital motion or for an analysis of the residual parallactic and orbital motion from a provisional ephemeris. In this case the positional results obtained on several nights may be combined into average values, referred to as normal points or normal places. Apart from the possible existence of systematic errors remaining constant over intervals covering a succession of several nights, weeks, or longer periods, a probable error of $\pm$ ".010 or smaller may be obtained for the normal places.

Experience with the long-screw measuring machines of the Sproul Observatory has shown that the measuring technique is generally quite stable. Repeated measurements seldom have revealed systematic differences over one micron in the measured positions of central star on reference background; most of these systematic differences are below half a micron. The accidental *error of measurement* of a plate is found to be about $\pm$ .0008 mm or $\pm$ ".015 (p.e.). This is part of the observed plate error of $\pm$ ".0274 (p.e.) mentioned above; the true plate error is therefore $\pm$ ".023 (p.e.). The average of two measurements of a plate increases the effective plate weight by a factor 1.15, three measurements by 1.25. The resulting gain is limited, and, generally, the additional effort is not warranted.[11]

3. *Analysis for proper motion and parallax.*

At the Sproul Observatory average values are formed of the plate solutions ξ, η for the different exposures on each plate. (Chapter III.) Means for each night are formed and added to the corresponding dependence center

$$[Dx_c],\ [Dy_c],$$

thus yielding positions X, Y which hold for the standard frame

$$(x_c,\ y_c).$$

We now analyze a series of measured and reduced positions X, Y for proper motion and parallax. The central star has been measured on a background of faint reference stars; the reduced positions refer to the dependence background of these faint stars of say magnitude ten, the resulting values for proper motion and parallax are called *relative*.

The equations of condition for a heliocentric path are

$$X = c_x + \mu_x t \text{ and } Y = c_y + \mu_y t. \qquad (1)$$

Here c_x, c_y is the heliocentric position at a certain zero epoch, say 1950.000, μ_x, μ_y the yearly proper motion; the time t in years is counted from the adopted zero epoch. The unit of time is the solar or Bes-

selian year, which begins when the right ascension of the mean sun is 280°. The Besselian fraction of the year is given in the *American Ephemeris* under independent star numbers.

The equations of condition for the observed geocentric path are

$$X = c_x + \mu_x t + \pi P_\alpha \text{ and } Y = c_y + \mu_y t + \pi P_\delta. \tag{2}$$

Here π is the relative parallax;

$$P_\alpha,\ P_\delta$$

(which more properly could be called P_x, P_y) are the parallax factors in right ascension (reduced to great circle measure) and declination, respectively, given by the relations

$$\begin{aligned} P_\alpha &= R\ (\cos\epsilon \cos\alpha \sin\odot - \sin\alpha \cos\odot) \\ P_\delta &= R\ \{(\sin\epsilon \cos\delta - \cos\epsilon \sin\alpha \sin\delta)\ \sin\odot - \cos\alpha \sin\delta \cos\odot\}. \end{aligned} \tag{3}$$

Here R is the radius vector of the earth's orbit expressed in astronomical units, $\odot$ the sun's true longitude, ϵ the inclination of the ecliptic on the equator, α the right ascension and δ the declination of the star. At the Sproul Observatory the positions are oriented close to the equatorial coordinate system of the year 2000, and

$$P_\alpha,\ P_\delta$$

must refer to this coordinate system. Hence in the calculations of

$$P_\alpha,\ P_\delta$$

the position α, δ is reduced to the equator and equinox of the year 2000: any appreciable effect of proper motion is applied up to the epoch of the observation. A precession correction of $+\,'.838$ (2000 — Epoch) is applied to the values of $\odot$ to refer them also to the equinox of the year 2000.

The formulae for the parallax factors are simplified by the following substitutions

$$\begin{aligned} p &= +\ .9174 \cos\alpha, & a &= +\ .3979 \cos\delta - .9174 \sin\alpha \sin\delta \\ q &= -\ \sin\alpha, & b &= -\cos\alpha \sin\delta \end{aligned} \tag{4}$$

whence

$$\begin{aligned} P_\alpha &= R\ (p \sin\odot + q \cos\odot) \\ P_\delta &= R\ (a \sin\odot + b \cos\odot). \end{aligned} \tag{5}$$

At the Sproul Observatory p, q, a, b, R, $\sin\odot$, $\cos\odot$ are used to four decimal places. The final values for

$$P_\alpha \text{ and } P_\delta$$

are used to three or two places. Tabular values for a and b have been published.[12]

The positions X, Y for each night are often corrected for provisional values of the unknowns c, μ, and π. This is done to facilitate the calcu-

lations and also to inspect the material for possible orbital motion. The equations of condition are assigned a night weight p, in accordance with the total plate weight and an assumed night error. The least squares solutions are carried out for the differential corrections, which afterwards are added to the provisional values, to yield the final values of c, μ, and π. All calculations are carried out in units of .0001 mm, the final results for the unknowns are reduced to seconds of arc by multiplying with the scale value (1 mm = 18".87 for the Sproul refractor).

4. *Results for parallaxes.*

The history of photographic determinations of parallaxes, as developed by Schlesinger and others, is well known. Long-focus refractors at several observatories are engaged in the determination of parallaxes of various groups of stars. The numerous proper motion stars, which continuously add to the knowledge of our immediate cosmic neighborhood, form an important portion of many parallax programs. As a rule, plates are taken near extreme parallactic displacement (shortly after dusk and before dawn) and generally only right ascension measurements are used, since they cover the greater part of the parallactic displacement. Some twenty or thirty plates, spread over a few years, yield a parallax determination with a probable error of about ± ".010 on the average. Reduction to absolute parallax is obtained by applying a statistical correction based on the mean parallax of the reference stars, taking into account their average magnitude, galactic latitude, and spectrum, whenever possible. For most long-focus parallax determinations the values for the reduction to absolute range from ".002 to ".007.

Analyses of sources of errors in parallax determinations were recently made by Dr. Alden and by Dr. Land.[13,14] These investigations dealt with the 1323 parallaxes observed at the Southern Station of the Yale Observatory from 1925 to 1935. Among the sources of errors studied there is a significant increase of the probable error of unit weight with the size of the reference configuration, also an increase in error, for the smaller, less blackened exposures and for very small sector openings. Dr. Land suggests that the average probable error of unit weight ± ".0245 for the Yale parallaxes could be reduced to ± ".0188, if all contributing sources of systematic effects could be eliminated in the observational technique. An optimum exposure time of 60 to 75 seconds is found to yield highest positional accuracy. This may be explained by the refraction oscillations with a period of roughly one minute, found by Schlesinger;[15] asymmetry in shapes and blackness of the images would occur for shorter and longer exposures.

5. *Trend to higher precision.*

Gradually a tendency has developed to increase the span of time and number of plates in individual parallax determinations, and thus improve the accuracy. This has resulted both from the desire for further improvement in the accuracy of the parallaxes and because of the gradual

extension toward other problems that are studied by means of the long-focus photographic techniques. We mention the long-range problems of orbital motion which include the determination of masses and mass-ratio (Chapter V), and the study of unresolved astrometric binaries (Chapter VI).

For illustration we review a recent summary of parallax determinations made at the Sproul Observatory.[4] The observations were more extensive than for most conventional parallax determinations, since the principal purpose was the study of orbital motion, both in right ascension and declination (see Chapters V and VI). The average number of plates for a series was 147, the average number of nights 57; the observations were spread over a decade or longer. One or two double plates per night, with up to four exposures per plate, were taken. As a rule three reference stars were used, occasionally four. The average inverse weight, $1 + [D^2]$, is 1.36. The average probable error of unit weight (one good plate with two exposures) is $\pm$ ".031; there is no measurable difference between the right ascension (x) and declination (y) determinations of this quantity. There is no pronounced dependence of the accuracy on the exposure time, or on the degree of magnitude compensation effected by the rotating sector. A slight dependence of accuracy on the size of the reference configuration is indicated in the sense that a wider spacing of the reference stars leads to a slightly diminished accuracy, especially if the spread is increased in the declination coordinate.

The plates were taken without special regard to the time of the night; the material is therefore not limited to extreme parallax factors in right ascension. As a result there was on the average more than the usual range of parallax factors in declination and the parallax values determined from the declination measures are of some significance, at least statistically; on the average the weight of the parallax determinations in declination (y) is 15% of those in right ascension (x). In nearly all cases, first, separate least squares solution in x and y were made for parallax and proper motion (and sometimes orbital motion). The separate parallax values generally were in satisfactory agreement and the adopted results for each star are based on the combined normal equations.

The probable errors of the parallaxes average $\pm$ ".0055 for the right ascension results, $\pm$ ".0120 for the declination results, and $\pm$ ".0050 for the results from the combined solutions. The Sproul results, reduced to absolute, average ".0008 $\pm$ ".0020 less than the values given in the 1935 *General Catalogue* of parallaxes.

6. Precision parallaxes.

As an example of a parallax determination of particularly high accuracy we mention the star of large proper motion BD + 5°1668 (7^h $24^m.4$, + 5° 32′, 1900; vis. mag. 10.1, sp. M4, $\mu = 3''.72$ in 170°).[16] A parallax determination was made from the material obtained with

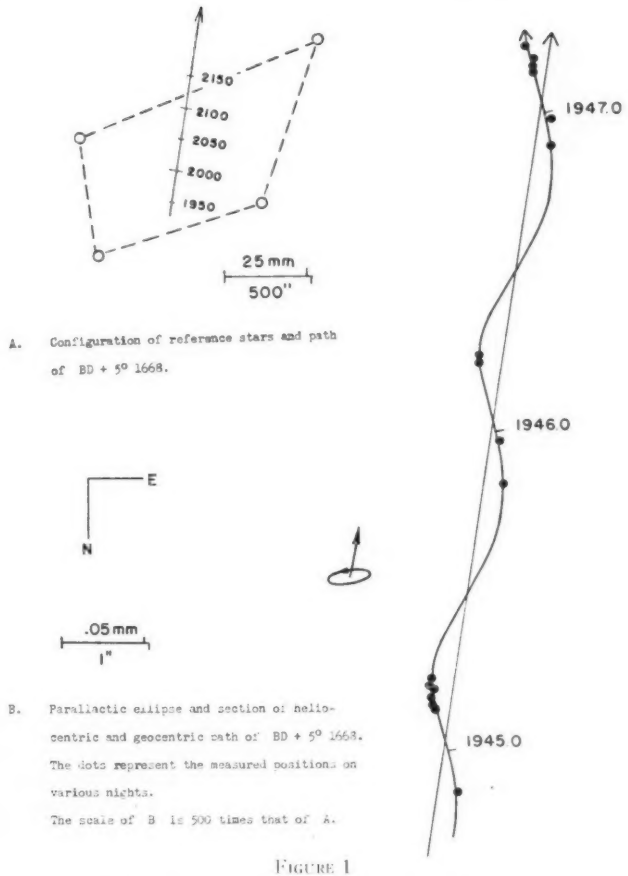

FIGURE 1

PROPER MOTION AND PARALLAX OF BD + 5° 1668.

Compared with the scale of the plates, path and reference stars (A) are reduced one-half, while the parallactic ellipse and section of the path (B) are enlarged 250 times.

the Sproul refractor over the decade 1937-1947. (Figures 1 and 2.) Four reference stars were used; because of the large proper motion the dependences were changed frequently.

Measurements were made on 379 plates with 1306 exposures, taken on 101 nights; the total night weight amounts to 275. The resulting values for the relative parallax are:

Right Ascension	$+''.2650 \pm ''.0023$,
Declination	$+''.2654 \pm ''.0114$,
Combined	$+''.2651 \pm ''.0022$.

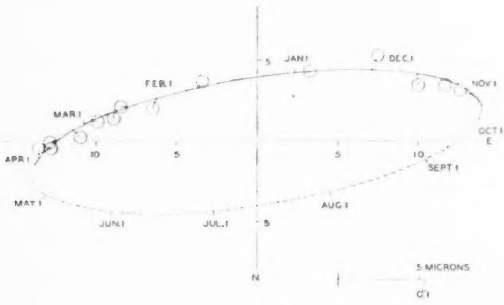

FIGURE 2

NORMAL PLACES (1937-1947) OF PARALLACTIC DISPLACEMENTS OF BD + 5° 1668. Enlargement from scale of plates 2500 times or ten times the scale of Figure 1 B.

To reduce this relative value to absolute we add the parallax of the reference background. For the average visual magnitude 10.1 of the reference stars, and the galactic latitude +12°, the mean secular parallax is ″.0135. Assuming a solar velocity of 20 km/sec, an annual parallax of ″.0032 is found. Reduced to absolute the Sproul value for the parallax of BD + 5° 1668 is therefore + ″.268. There is excellent agreement with other photographic values adjusted for Schlesinger's systematic corrections; they are + ″.263 ± ″.008 (van Vleck), + ″.264 ± ″.010 (McCormick), and + ″.262 ± ″.008 (Yale).

The residuals after allowing for parallax and proper motion are small; they are represented by a probable error of unit weight of only ± ″.025. The residuals were combined into yearly normal places, which are given below.

Epoch	Mean Residual in x	Mean Residual in y	Total Night Weight
1938.05	+ ″.004	— ″.002	19
39.09	— 11	— 2	43
40.04	0	— 5	76
41.11	+ 11	+ 8	39
41.97	+ 8	+ 12	18
43.20	+ 10	— 5	11
44.03	+ 2	+ 2	25
45.14	— 18	— 2	21
46.04	— 5	— 16	11
47.12	+ 8	— 3	12

The average probable value of the yearly mean residuals is ± ″.0063, which is slightly more than the probable error ± ″.0047, computed from the probable error of unit weight ± ″.025 and the average weight 27.5 of the normal places. Neither this slight discrepancy nor an inspection of the run of the residuals presents conclusive evidence for the reality of a measurable perturbation for this star.

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CHAPTER V

PARALLAX, ORBITAL MOTION, AND PROPER MOTION; MASS-RATIO

Let us consider the path of a star, including the motion caused by a companion. We must take into account the measured orbital effects relative to the barycenter of primary and companion. Of special interest is the determination of the *scale* of the orbit, both in the problem of mass-ratio and in the dynamical interpretation of unresolved astrometric binaries. In the present chapter we shall assume all orbital elements to be known except the measured, angular, semi-axis major of the observed orbital motion, which is related to the scale of the relative orbit of the two components through their mass-ratio and, in case of blending, their luminosity-ratio.

As far as proper motion is concerned, the secular parallactic and peculiar (individual) motions combine into the total proper motion; generally it is not possible to separate these component motions. The situation is different for the annual parallactic and the orbital motions which usually can be separated. The parallactic motion enters as a full-size relative orbit of Sun and Earth; the semi-axis major in the true parallactic orbit is one astronomical unit, revealed in angular measure as the annual or heliocentric parallax.[1,2]

1. *Orbital motion of primary relative to barycenter.*

The star's orbit is revealed as a fraction of the relative orbit of companion and primary. We recall that for the relative orbit of companion and primary the relation between the "equatorial" rectangular coordinates and the orbital elements is as follows:

$$\begin{aligned} \Delta x &= Bx + Gy \\ \Delta y &= Ax + Fy. \end{aligned} \tag{1}$$

Here

$$\begin{aligned} x &= \cos E - e \\ y &= \sin E \sqrt{1 - e^2}, \end{aligned} \tag{2}$$

while B, A and G, F represent the equatorial rectangular coordinates of periastron, and of the point $E = 90°$ in the auxiliary circle, all referred to the center of the relative orbit as origin. The geometrical constants B, A and G, F are proportional to the scale a, *i.e.*, the semi-axis major of the relative orbit[3,4,5] (Chapter II).

For the orbit of the primary around the barycenter the dynamical elements P, e, T are the same; the semi-axis major of the orbit is reduced to the scale α. The orientation elements Ω, ω, and i are defined for the orbit of companion relative to primary. The star's orbit is revealed as a fraction α/a of the relative orbit of companion and primary, the radius vector differing at all times 180° in position angle.[6] Hence the equatorial rectangular coordinates of the orbital motion are represented by the expressions:

$$-(\alpha/a)\,\Delta x \text{ and } -(\alpha/a)\,\Delta y. \tag{3}$$

If the observed orbital effects refer to the position of a primary component, unaffected by a well-separated or dark secondary, then the semi-axis major α of the orbit of the primary is related to the semi-axis major a of the relative orbit of primary and companion as follows:

$$\alpha = \mathrm{B} \times a \tag{4}$$

where B is the fractional mass

$$\frac{M_B}{M_A + M_B}$$

of the companion in terms of the combined mass of primary and companion. Hence the orbital effects (3) may also be written as

$$-\mathrm{B}\,\Delta x \text{ and } -\mathrm{B}\,\Delta y. \tag{5}$$

2. *Orbital factors.*

In the analysis for parallax, the effects in R.A. and Decl. are represented by

$$\pi P_\alpha \text{ and } \pi P_\delta;$$

here π is the relative parallax, while the parallax factors

$$P_\alpha,\ P_\delta$$

are the projected values in R.A. (reduced to great circle) and Decl. of the radius-vector Sun-Earth, expressed in astronomical units. In the analysis for orbital motion, the orbital terms in R.A. (reduced to great circle) and Decl. may be expressed in an analogous manner by introducing orbital factors

$$Q_\alpha,\ Q_\delta,$$

which are the projected values in R.A. (reduced to great circle) and Decl. of the radius-vector primary-barycenter, reduced to the scale unity.

Hence we have[6]

$$\text{Orbital effect in R.A.: } \alpha Q_\alpha, \text{ in Decl.: } \alpha Q_\delta. \tag{6}$$

where

$$Q_a = (b)\, x + (g)\, y$$
$$Q_b = (a)\, x + (f)\, y. \tag{7}$$

Here x and y are functions of the dynamical elements only, while (b), (a) and (g), (f) are functions only of the orientation elements as follows:

$$\begin{aligned}(b) &= -\cos\omega\sin\Omega - \sin\omega\cos\Omega\cos i\\ (a) &= -\cos\omega\cos\Omega + \sin\omega\sin\Omega\cos i\\ (g) &= +\sin\omega\sin\Omega - \cos\omega\cos\Omega\cos i\\ (f) &= +\sin\omega\cos\Omega + \cos\omega\sin\Omega\cos i.\end{aligned} \tag{8}$$

The orientation factors (b), (a) and (g), (f) represent the equatorial rectangular coordinates of periastron, and of the point $E = 90°$, for the auxiliary orbit of primary relative to the barycenter, reduced to scale unity. They are related to the Thiele-Innes constants as follows:

$$\begin{aligned}B &= -(b)\, a\\ A &= -(a)\, a\\ G &= -(g)\, a\\ F &= -(f)\, a.\end{aligned} \tag{9}$$

In expressions (6) and (7) an explicit separation exists therefore between scale, dynamical, and orientation elements.

3. *Formulae for proper motion, parallax, and orbital motion. Unresolved astrometric binaries; photocentric orbit.*

The formulae for analyzing the positions of the primary component for proper motion, parallax, and orbital motion, are therefore:

$$X = c_x + \mu_x t + \pi P_a - \mathrm{B}\,\Delta x$$
$$Y = c_y + \mu_y t + \pi P_b - \mathrm{B}\,\Delta y, \tag{10}$$

or

$$X = c_x + \mu_x t + \pi P_a + \alpha Q_a$$
$$Y = c_y + \mu_y t + \pi P_b + \alpha Q_b. \tag{11}$$

In many cases the distance between the components is below the resolving power of the photographic plate, in which case no separation is possible and a composite image results. These photographically unresolved astrometric binaries are important, since so many interesting objects fall in this group. We can measure the position of the composite image, but these questions arise: What do we measure? What do the measures signify?

The smallest star images on long-focus photographs are rarely below 1″ in diameter; blended exposures of components separated 1″, or sometimes even more, generally present circular images.

We assume that the measured position of the blended image represents the weighted center of light intensity or *photocenter* of the components. In this case the fractional distance β of the primary to the photocenter, in terms of the distance between the two components is given by

$$\beta = \frac{l_B}{l_A + l_B}. \tag{12}$$

Here l_A and l_B are the luminosities of the components. Or, if we introduce the difference in magnitude Δm, companion *minus* primary, we have[7]

$$\beta = \frac{1}{1 + 10^{0.4\Delta m}}. \tag{13}$$

The fractional difference of photocenter to barycenter is therefore $B - \beta$, and the semi-axis major of the *photocentric orbit* relative to the barycenter is[1,2]

$$\alpha = (B - \beta)\, a. \tag{14}$$

Referred to the barycenter, the orbits of primary, companion, and photocenter are all similar to the relative orbit of companion relative to primary in the ratios B, $1 - B$, and $B - \beta$ (Figure 1).[8] Note that α

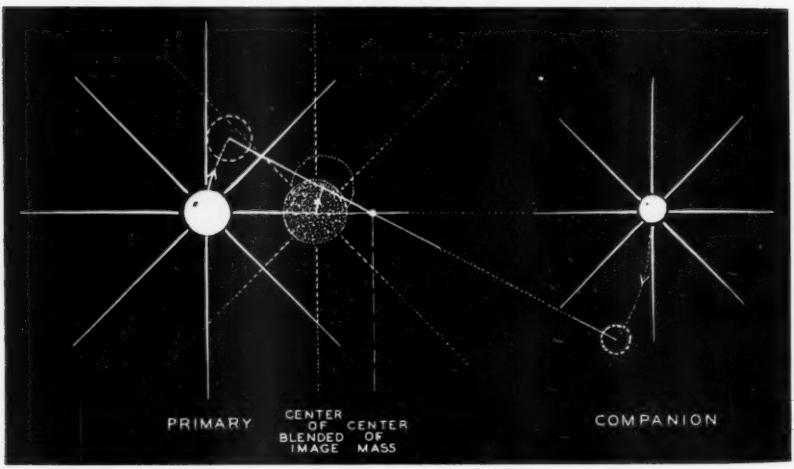

FIGURE 1

This sketch illustrates the location of the measured photocenter of an unresolved astrometric binary, relative to primary, companion, and barycenter. The relative spacings are as follows:

primary	— companion	: 1
primary	— barycenter	: B
companion	— barycenter	: $1 - B$
photocenter	— barycenter	: $B - \beta$

has the sign of $B - \beta$. A positive value for α indicates that photocenter and companion are on opposite sides of the barycenter, a negative value, that they are on the same side.[6] Except for the abnormal possi-

bility, that $\beta - B > B$, the photocentric orbit is always smaller than the orbit of the primary.

The orbital effects may also be represented by

$$-(B-\beta)\,\Delta x, -(B-\beta)\,\Delta y, \tag{15}$$

but the form

$$a\,Q_a,\ a\,Q_b \tag{6}$$

remains of particular value because of the explicit way in which a appears.

The more general formulae for analyzing the positions of the photocenter for proper motion, parallax, and orbital motion are therefore

$$\begin{aligned} X &= c_x + \mu_x t + \pi P_a - (B-\beta)\,\Delta x \\ Y &= c_y + \mu_y t + \pi P_b - (B-\beta)\,\Delta y, \end{aligned} \tag{16}$$

or

$$\begin{aligned} X &= c_x + \mu_x t + \pi P_a + a\,Q_a \\ Y &= c_y + \mu_y t + \pi P_b + a\,Q_b. \end{aligned} \tag{17}$$

4. *Mass-ratio.*

Formulae (10), (11) or (16), (17) are suitable for determinations of the *mass-ratio,* (or rather the fractional mass B), for binaries whose orbital elements are well known. We may calculate Δx, Δy and determine B or $B - \beta$ by means of formulae (10) or (16), respectively; in the case of both components visible and separated on the photographic plate, the orbit need not be known, since the Δx, Δy are directly furnished by the measurements.[9] Or the dynamical and orientation elements are used to compute the orbital factors,

$$Q_a,\ Q_b;$$

applying formulae (11) or (17) a determination of a is then made, whence the fractional mass of companion is obtained, in the general case, from formula (14) written now as the simple, explicit relation[6]

$$B = a/a + \beta. \tag{18}$$

We must make certain that the orbital motion is well separated from the proper motion and the annual parallactic motion. As a general rule, some 50 good plates, covering a curvature of about ″.5 in the relative orbit, will give B or $B - \beta$ with a probable error of about .02.[10] For the general case the correction for β remains a serious uncertainty.[11] Experiments with artificial double stars have shown deviations of as much as .05 from the calculated values by the formula (13).[12,13]

An illustration will be given for the binary 99 Herculis (ADS 11077; $18^h\,3^m.2$, $+30°\,33'$, 1900).[14] This star was photographed at the Sproul Observatory during the years 1915-1917, and again from 1937 on. The period is 56 years; periastron was passed in 1942; hence sufficient orbital motion for an accurate mass-ratio determination is covered by the 89 plates taken on 38 nights between 1915 and 1947 (Figure 2). A set of three reference stars was used, the image of 99 Herculis re-

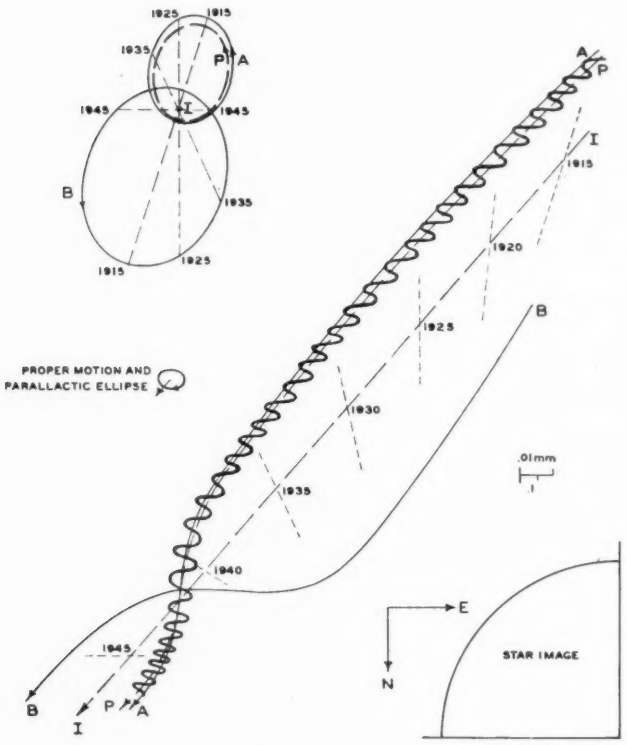

FIGURE 2

PROPER MOTION, PARALLAX, AND ORBITAL MOTION OF 99 HERCULIS (1915-1947).

This diagram illustrates the geocentric and heliocentric paths of the photocenter P, and the heliocentric paths of the components A and B and their center of mass I.

In the upper left are shown the paths of P, A, and B around the center of mass, and also the proper motion and parallactic ellipse.

Enlargement from scale of plates 500 times.

duced to close equality, 10.1 mag., with that of the reference stars by the use of rotating sector of 1.0 per cent opening. The separation of the components never exceeded 1".5 or about .09 mm; the difference in magnitude between the components is 3.4 mag.

The mean positions for each night were represented by the equation (17) in which the orbital factors were computed from the elements for the relative visual orbit of companion and primary:[15]

$P = 56^{y}.0$	$e = .76$	$T = 1942.00$
$\Omega = 55°.8$	$\omega = 105°.0$	$i = 32°.0.$

The results for π and a from a combined solution of the R.A. and Decl. material are

$$\pi = +\,''069 \pm ''006$$
$$a = +\,''344 \pm ''009.$$

The relative orbit gives $a = 1.''03$; using formula (18) we obtain

$$B = +\,.334 + \beta.$$

With the value of 3.40 for Δm we derive $\beta = .040$ (formula 13) and hence $B = .374$ with a probable error $\pm .009$ due to the astrometric determination of a.

The sum of the masses is computed by means of the harmonic relation

$$M_A + M_B = a^3/P^2, \qquad (19)$$

where a is the semi-axis major of the relative orbit, expressed in astronomical units, P the period in years; the masses are referred to the sun's mass as a unit.

Combining the above value of the parallax with others, a value of ".055 is adopted for the parallax of 99 Herculis, yielding 2.0 ⊙ for the sum of the masses of the components. Hence the mass of 99 Herculis A is 1.3 ⊙, that of 99 Herculis B is .7 ⊙. The mass-ratio is probably more accurate than the masses themselves, since any error in the parallax appears threefold in the sum of the masses.

Mass-ratio studies with long-focus instruments are being made at the McCormick, Sproul, and Yerkes Observatories.

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(To be continued)

Suggested Improvements in Sunrise-Sunset-Twilight Tables

By CHARLES H. SMILEY

The rather simple conventions used in the temperate zones for determining the times of sunrise (or sunset) and of the beginning (or end) of twilight at or near sea level are inadequate at heights, especially in the Arctic and Antarctic areas. They are not very satisfactory even at the surface in the tropics and in the polar regions. This report is intended to point out some of the difficulties and discrepancies and to suggest methods of improving upon the conventional approaches to the problems. It is hoped that it will serve as a basis of discussion of the problems involved and perhaps lead to some positive action being taken toward their solution. Some of the changes suggested here are based on the results of work on atmospheric refraction undertaken at Ladd Observatory of Brown University with the cooperation of the Office of Naval Research.

Sunrise and Sunset at the Surface of the Earth

The tables of sunrise and sunset times available in the American Nautical Almanac, The American Ephemeris and Nautical Almanac, and, indeed, in most other well-known national ephemerides are based on the assumption that from the surface of the earth, the first glimpse of the sun at sunrise and the last view at sunset will be had when the center of the sun is 50′ below the mathematical horizon. For refraction 34′ is allowed; for semidiameter 16′. No allowance is made for the temperature likely to be associated with the latitude. If separate tables are provided for the northern and southern hemispheres, allowance might also be made for the probable temperature at the indicated time of year.

For observers at sea level in latitudes 26° to 55° (N or S), the assumptions listed above are not unsatisfactory, but for sea level in latitudes 25° S to 25° N, with air and water temperatures in the neighborhood of 80° F, it would be better to assume the center of the sun 47′ below the mathematical horizon, *i.e.*, 31′ for refraction and 16′ for semidiameter. This would have the effect of shortening the sunlit period of the day by 1½ minutes. There would be little advantage in changing the amount allowed for refraction at different times of the year since the seasonal changes of temperature in the tropics are slight.

For sea level in latitudes 56° to 90° (N or S) one might use 55′ instead of the usual 50′ and in the coldest part of the winter when the temperature is down around —20° F, say in December, January, and February in the far northern latitudes, this might be increased to 60′.

There appears to be no good reason why the tabulated times of sunrise and sunset at sea level given in the various national ephemerides

should not take into account, at least in part, the change in refraction due to temperature-change in terms of latitude and time of year.

Twilight at the Surface

The old definitions of twilight are arbitrary and not closely tied to reality. The intervals when the sun is less than 6°, less than 12° and more than 6°, and less than 18° and more than 12° below the horizon have been called civil, nautical, and astronomical twilight, respectively.

There are two phenomena which might be used to define nautical twilight; a reasonable definition might have it last from the time one can easily see first magnitude stars in a clear sky (perhaps based on a statistical study by navigators or other persons who know where the stars are likely to be found) to the time when the ocean horizon can no longer be seen in a direction of bearing 90° different from that of the sun beneath the horizon. Research by the Germans during the last war indicated the horizon could be seen until the sun was 8° 51′ below the horizon.

The end of astronomical twilight in the evening might possibly be defined as the time when an observer with dark-adapted eyes could see stars of magnitude 5.0, or the Milky Way (assuming it passes within 15° of the zenith at the time), or it might be defined in terms of the measured brightness at the zenith (or at a point not in the Milky Way but within 15° of the zenith).

It is to be understood that for practical usage, the above definitions would have to be translated into other statements based on the position of the sun beneath the horizon. This could be done by statistical studies similar to that by which the Germans reached 8° 51′ as the limiting depression of the sun at which the horizon could be seen.

Sunrise and Sunset at Heights

The conventions now being used in computing sunrise (or sunset) times at heights are those of the British Nautical Almanac Office. They appear not to be closely related to reality; in particular the curvature of the refracted ray used is a calculated one based on Ivory's hypothesis. It may be pointed out that refraction tables based on Ivory's hypothesis do not agree with the observed values of refraction at low altitudes. It would be possible to replace these conventions by others based on data gathered when the sun is observed at negative altitudes. Three steps would be required. First the negative altitude of the horizon should be measured when the observer is at a series of known elevations above sea level; this can be done with certain types of bubble octants which will continue to function to negative altitudes of the order of 5 degrees. Secondly the refraction at the horizon can be determined by measuring the changing vertical diameter of the sun as it sets and integrating downward from an altitude at which the refraction is small and reasonably well known. Thirdly the mathematical altitude of the sun can be computed for the known longitude and latitude of the observer at the instant the upper limb of the sun disappears below the

horizon. Thus one has a check on his work which yields an observed value for the depression of the center of the sun below the mathematical horizon at a point on the surface directly beneath the plane.

It is customary to assume that as the upper limb of the sun disappears below the horizon, the last ray of light passes tangent to the earth. This may not be true even on a perfectly clear day; this assumption, like the others, should be re-examined with care.

Beginning or end of Twilight at Heights

Again the conventions used in calculating the times of beginning or end of twilight as published in the American and British Air Almanacs are due to the British and "the assumption [on which they are based] has little or no physical foundation." The problem of replacing this arbitrary assumption by one resting on a sound observational basis is not a simple one; however, its importance would warrant a considerable expenditure in time, energy, and money.

A part of the problem consists in determining the curvature of a refracted ray of light arriving from a celestial body at a low angular altitude. This can be done by repeating at several different elevations above sea level, the determination of the atmospheric refraction corresponding to a number of different low altitudes. Ideally it should be done in several latitudes representative of the principal geographical zones.

Next there is the matter of the extinction of the light of the sun as the sun reaches lower and lower altitudes (including negative ones for this problem); the part of this which is due to the varying thicknesses of the earth's atmosphere through which the light passes can be handled with relative ease but the determination of the varying transmission and scattering of light by the atmosphere is a complex problem. One needs only to watch the setting sun from day to day to realize this; on two days which appear to be equally clear, the brightness of the sun at setting may be vastly different. On one day, the sun may touch the horizon a bright yellow ball, the next day a deep red.

Also there is the varying reflectivity of the cloud surfaces and masses of water, ice, or snow. This will play an important part in the Arctic. The visibility of ice blinks from the surface is good proof of this. The transparency of the polar air masses and the scattering of light by them would tend to make the "sky light" and the "ground light" of the Arctic essentially blue. The selective absorption of light and the scattering of light will make the Arctic problem a difficult one.

Conclusion

A series of observations should be made at selected elevations in a number of representative latitudes with a view to establishing a new set of definitions of the three twilights and a better set of conventions to be used in calculating the times of sunrise and sunset and beginning and end of the various kinds of twilight at sea level and at heights.

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Another Look at the Comet Problem

By H. H. NININGER

The idea of a relationship between comets and meteorites is one of long standing, relative to the age of the science of meteoritics. It has been believed that the bright gaseous-appearing nucleus of a comet is composed of a swarm of meteorites traveling together in an orbit around the sun. The luminous tails of comets are considered to be gaseous particles streaming away from the swarm under pressure of light.

In a number of cases, sufficient to give credence to the association, the near approach of comets to the earth has been accompanied by meteoric showers of varying intensity. The periodic showers of the Perseids, the Leonids, and the Orionids, to name but a few, all occur in connection with old comets, the last named being observed with the passing of the famed Halley's comet.

This phenomenon has been explained as the result of the comet's passing close enough to the earth so as to render some of its components susceptible to the earth's gravitation, with the result that they are brought into our atmosphere and, presumably, to the soil if sufficiently large to survive; although concrete evidence on this last point has been difficult to secure. Since meteorites are known to be responsible for individual meteor phenomena, it seemed evident that meteorites must compose the showers as well, and logically, then, the cometary swarm itself.

Now, however, new theories are being set forth whereby the explanation of comets as swarms of meteorites is being discarded, if not entirely, at least to the extent of radically changing the conception of what kind of meteorites make up the swarms. Briefly, these theories conceive of comets as being composed of ices and similar unstable substances, rather than the iron and stony materials known in meteorites.

While I do not feel qualified to pass upon the validity of these concepts, I do have very definite opinions, based upon well-established facts, regarding some of the reasons that certain astronomers have set forth for feeling that the older concept must be discarded. It would seem advisable, therefore, to evaluate these facts before doing away with the old meteoritic concept altogether.

This can best be done by answering the two principal objections to the meteorite swarm theory as an explanation of comets which have been voiced from time to time by eminent astronomers and which are now being stressed as positive evidence in support of the new theories. One, that although man has experienced many meteor showers in connection with comets, no meteorite has ever been known to reach the earth during such a shower. The other, objecting to the conception that cometary encounters are the source of lunar craters, because no change has ever been observed to occur on the moon.

The new theories purport to account for both of these objections by claiming for comets a nature of which no such results could be expected. It remains, then, for me to challenge the validity of the objections with respect to meteorites by reiterating certain well-established meteoritical facts.

Many astronomers had their faith shaken because no meteorites were collected from the Giacobini-Zinner comet at the time of the magnificent shower of October 9, 1946. They also refer to the meteor showers of 1866 and 1833 and wonder why no meteorites were recovered at the times of those displays if meteor showers were due to meteorites.

I, too, was disappointed on October 9, as I have been many another time. I have been disappointed in the fact that even though I have devoted practically all my time since November, 1923, to meteorites I have never been fortunate enough to see one hit the earth. But estimates calculated to establish the frequency of meteors observed in our atmosphere in relation to the number of meteorites recovered from the soil render my disappointment not only comprehensible but something to be expected.

The earth encountered probably a half-billion meteorites during the best two hours of the Giacobini shower. Yet none was proven to reach the soil. Disappointing as this may seem, it is understandable in the light of other well-known facts. During the forty nights previous to the shower the earth had encountered an equal number of meteor-producing meteorites, none of which was recovered. And a like number occurred during the forty nights previous to that, and so on back. In fact, it has been fifteen years since a meteorite was recovered from a night fall in the United States.

During those fifteen years, 120 billions of meteorites comparable in magnitude to those of the Giacobini shower have been intercepted by our planet. About half of these were night encounters, such as occurred in that shower. About a dozen out of the sixty billion daylight encounters were recovered, but not one of the sixty billion nighttime arrivals was ever found, probably for the same reason that none was recovered from the spectacular Giacobini shower. It should be remembered that the recovery of a meteorite is always dependent upon a great many factors, not the least of which is a witness who is well qualified to evaluate his observations. Obviously, a night fall precludes such accuracy and is consequently seldom recovered.

This immediately suggests another very important consideration, namely, the question as to why all of the famous meteor showers on record have been at night. This cannot mean, of course, that meteor showers occur *only* at night. It is simply that those which take place in daylight are not famous because no one has ever seen them. Doubtless as many great showers have occurred in daylight as at night, but they have never been recorded because they are unknown.

In view of these facts, who can say that no meteorites have ever been

recovered from any "meteor shower"? According to the records of daylight and night falls recovered, the chances are at least five or six to one against our knowing it if a recovered meteorite is the product of a meteor shower. And it is a foregone conclusion that if an arrival occurred during an uncharted daylight shower of the same magnitude as the nocturnal showers, no one would ever know of the association.

But such calculations, scientifically sound as they may be, are not the only evidence against the claim that meteorites never fall during meteor showers. The records themselves indicate the contrary.

According to L. Fletcher[1] of the British Museum, writing in 1890, the Mazapil iron fell during the Bielid nocturnal shower of November 27, 1885, when it was estimated that 75,000 meteors were visible from a single location during a one-hour period. Hidden[2] gave a very good account of this recovery only two years after its occurrence.

Henry A. Ward[3] called attention to the fact that the Bath Furnace meteorite fell on November 15, 1902, at 6:45 P.M., the proper time for the Leonid shower. He also notes that Verkhne, Tschirskaia, Russia, fell on November 12, 1843, which again was well timed for the Leonid shower according to the precession table prepared by Newton. Saline was considered by Farrington[4] to have been deposited by the great fireball seen on November 15, 1898, in that locality.

Fletcher Watson[5] has called attention to the fact that a list of cometary meteor showers prepared in 1925 would not have included the Giacobini shower. Doubtless many other such swarms unknown to man touch upon or closely approach the earth's orbit, and it is not unreasonable to assume that some of the recovered daylight falls have been associated with such unknown showers.

One of the things which seems very difficult for astronomers and geologists to remember is that when working on meteoritical problems a great deal of time is necessary for the securing of significant data. A geologist may look about him and see dynamic phenomena always observable. Even though the processes may take place slowly, they are continuous and always present in some part of his environment. An astronomer always has the stars and the galactic phenomena if the weather is clear. But for the meteoriticist, most of the happenings are instantaneous and widely scattered, both geographically and in point of time. We dare not try to rush our conclusions.

The second objection that has been offered to the existence and activity of meteorite swarms is that no change has ever been seen to occur on the moon, of any origin whatever, let alone as a result of cometary bombardment by meteorites. I shall make no attempt to evaluate recent observations on that satellite further than to remark that those who have spent most time observing it telescopically have been the most insistent that changes do occur. But at least two very well-known cases of change are on the records.

Craters of observable size would scarcely be formed on the moon

more often than once in a century, and the majority of cometary swarms would not produce noticeable marks except by way of obliterating craters previously formed. It is apparent that exactly such an event was chronicled in 1860 by the eminent selenographer, Dr. Schmidt, and was subsequently verified by his contemporaries. Probably not since their time and certainly not during our generation have there been such devoted students selenographically. Their maps of the moon were executed with the utmost regard for detail, and they were completely familiar with lunar topography as revealed by the telescopes of the day.

Dr. Schmidt was astonished one day when looking at the moon through his telescope to find Crater Linné missing, and in the place of the six-mile crater a light gray spot of indefinite outline. He announced the change and it was verified by others. This gray spot is still a conspicuous object in the Mare Serenetatis. Its appearance replacing the Linnéan Crater can best be explained by the arrival at that point of a cometary swarm of bodies sufficiently large to churn up the moonscape but none of which was large enough to develop an individual crater of sufficient size to be observed from the earth.

In the Monthly Notices of the Royal Astronomical Society of London is recorded the observation of Mr. Hodgson of Fir Grove, Eversley. On December 11, 1847, Hodgson reported "a bright spot, about one-fourth the angular diameter of Saturn was perceived, which, though it varied in intensity like an intermitting light, was at all times visible." On this occasion Hodgson was using an achromatic telescope of sixty-inch focal length and powers fifty to eighty. On the following day glimpses of the same spot were caught between passing clouds with a Newtonian reflector, power forty.

Evidently no distinct visible crater was formed in this instance or a record would have been made. However, if a pool of white hot lava had been produced by a meteoritic impact it could have been visible while brightly glowing even though of dimensions too small to be observed after the light had disappeared. Again it might be explained by the formation of a number of small lava pools, each a few yards in diameter. When the glow had faded no trace of the phenomenon would have been discernible.

While it is possible that such an observer was mistaken it is certainly not a scientific attitude to ignore such reports, but rather to follow them by protracted and widespread observations. Our generation of astronomers has been notably neglectful of serious lunar studies. There is little reason to believe that intensive study of the moon would go unrewarded in the matter of revealing visible changes on its face.

Whatever may be our evaluation of such lunar observations we can hardly ignore the undeniable scars left on the earth by groups of meteorites such as produced the thirteen craters in Central Australia, the two near Wabar, Arabia, the three at Odessa, Texas, the six in Estonia, or the two groups produced in Siberia in 1908 and 1947, re-

spectively, each consisting of more than thirty craters. One should also mention the great aggregation of elliptical depressions in the coastal plain of southeastern United States which are regarded by many as meteoritic.

That so many groups have encountered the land surface of the earth within recent geologic time is positive indication of a rather intensive bombardment by meteoritic groups or swarms; hence such swarms must exist in great numbers in space and must be even more of a hazard to the unprotected surface of the moon.

Perhaps some comets do consist of ices or a combination of ices and the more durable forms of meteorites with which we are familiar; but that groups of irons and stones traverse our orbit is no longer theory, but well-established fact. More evidence is needed to prove beyond a doubt the connection of comets and meteorites, but in our haste to embrace a new idea, let us not overlook the factual evidence already at hand.

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The Origin of the Carolina Bays and the Oriented Lakes of Alaska

By ALLAN O. KELLY

The "Carolina Bays" have been the subject of discussion in a number of papers in this magazine in the last few years. Here is another paper in which a new point of view is presented as an explanation of them. The degree of conviction induced by this argument will, no doubt, vary with the experience, background of thinking, and subjectivity of the reader. Editor.

The origin of the Carolina Bays and the Oriented Lakes of Northern Alaska is a problem that has long intrigued the scientific world. Probably the great interest in this scientific puzzle arises from the fact that Melton and Schriever, geologists from the University of Oklahoma, who first discovered the Carolina Bays, attributed them to a gigantic shower of meteorites. This interpretation was made in 1933. Such a spectacular theory immediately aroused the interest of the Press and several articles appeared in popular magazines describing the fearful holocaust that must have occurred. Following this introduction to the public, the scientific world began to investigate. Many different hypotheses were proposed but none seemed to fulfill all the requirements.

Dr. Douglas Johnson, geologist of Columbia University, said of these bays or depressions: "They are without doubt one of the most remarkable geomorphic features on the surface of the earth. They share with submarine canyons the distinction of being among the most difficult of earth forms to explain." Johnson was unaware of the Oriented Lakes of Alaska.

The Oriented Lakes of Northern Alaska were first investigated by R. F. Black and W. L. Barksdale of the United States Geological Survey. They published a rather complete article about these lakes in the *Journal of Geology* in March of 1949. They did not propose a complete theory of origin but they did give a table of comparisons between the Carolina Bays and these lakes. It was shown that out of 17 items of comparison, the two groups were similar in all but five. Among other things they concluded that "The Carolina Bays and the Oriented Lakes of Alaska are so strikingly similar that it is believed that the conditions operating to produce them must have been, at least in part, similar." No one else, so far as we know, has made any investigation or any proposal as to the origin of these lakes.

It is not our purpose in this short article to criticize other theories of origin but rather to advance one which we believe answers all of the requirements, so far as we know them.

This theory is based on cosmic collision as the motivating energy that produced these bays or lakes, and, in fact, the force that has produced most of the physical features of the earth. Such collisions and the oceanic floods that must have followed, can explain every unexplained problem of modern geology, including submarine canyons. Many thousands of these collisions have occurred in the earth's long history and the last major one caused the Biblical Flood which is also recorded by many other races of people. The physical evidences of this last great flood are found all around the world, in tremendous gravel deposits in unusual locations; in old shore lines high above the present levels of inland lakes such as Great Salt Lake and the Dead Sea; in recent glaciation and evident change of climate; in prehistoric animals found frozen in the Arctic, and a vast array of other physical evidence that cannot be mentioned here.

The Carolina Bays and Oriented Lakes of Alaska are only a small part of this great array of collision evidence, but they are the immediate concern of this article and one more step in proving the collision theory. Our reasoning is as follows: Before this last great catastrophe, the North Pole was located near Apatak Island in Hudson Strait. This fact is proved by drawing an arctic circle around this point, which is then found to contain all the glaciated area of North America, including Greenland and Iceland. These two islands were in practically the same relative position to the old arctic circle as they are today, so that their ice conditions have not changed.

It will be seen, then, that a considerable part of the North Atlantic

was well within this old arctic circle and so must have contained large quantities of sea ice and glacial ice. On the other side of the circle, the Arctic Ocean also was in a position suitable to the production of ice.

The meteorite or asteroid, which caused this last cataclysm, struck the earth at a point which was then just outside the arctic circle but now off our South Atlantic Coast. It formed a great under-sea crater whose outlines can be traced for hundreds of miles as a nearly perpendicular wall (Figure 1). When this collision occurred it moved the surface of the earth in relation to the rays of the sun and at the same time changed the axis of the earth to its present location. A new alignment would certainly follow if the striking body penetrated the crust of the earth

FIGURE 1

and added its weight to one side of the earth flywheel. On the other hand, if it only struck a glancing blow, the earth would probably wobble a little like a spinning top and soon regain its former axis. All the evidence seems to indicate that this object did penetrate the crust of the earth.

Such a collision would, of course, cause a terrific earth shock felt all over the world. The polar ice cap would have been shattered and the oceanic flood that followed would have floated vast quantities of ice far away from its source. Geologists have estimated the ice over Hudson Bay to have been over two miles thick. This ice and the ice in the Great Lakes apparently melted in place but the old polar cap was elevated and the ice moved off the land in all directions as the grooves in the rocks so plainly indicate. The glacial ice and sea ice that was floated by this flood must have rushed back with these waters to fill the impact point. This ice would have melted quickly in such an inferno* but some of the sea ice far away near the coast of Greeland might have trailed far behind and missed this hot water bath. This ice could have been stranded like a great fleet of ships, for wind and tide would have tended to orientate them to some degree. When they grounded on the coastal plain, the seaward end of each berg or cake of ice would float more easily. Thus the bergs were grounded or anchored like ships in a harbor and would swing with the tide, all pointing in the same direction as the outgoing tide. As the tides receded, there came a time when the bergs failed to float on the incoming tide and so remained in this fixed position until melted.

Once the stranded bergs were firmly fixed on the bottom, the tides began to shape the land surfaces between. Since ice floats with about nine-tenths of its mass below the surface, this grounding would take place while the tidal floods were still quite deep for these cakes of ice might have been several hundred feet thick, judging by Antarctic sea ice. The ice in the Carolina Bay region probably remained for a year or so after the tides had returned to normal but in Alaska, they may have remained hundreds of years before melting completely.

The length of time that might have passed before the tides returned to normal would be difficult to determine by geological observation but the Biblical account of the Deluge tells us that the waters were "Going and returning continually for one hundred and fifty days." This seems like a reasonable estimate of the time that might have been required.

Major Chapman Grant, of San Diego, California, who visited the Carolina Bays in 1948, describes the area as not really a flat plain but a region in which low gravel hills are interspersed with Bays of a little lower elevation and with stream channels a little lower than the Bays. He also pointed out that seldom, if ever, does a stream flow from one bay to the next as is the case in all other lake country, but always around the Bays. In like manner the gravel hills do not encroach upon the

*The Finns have a legend of a hot water flood.

bays nor do the so-called beach ridges. Johnson and others were at a loss to explain why these old surf lines or beach ridges, as they called them, did not cross the bays for the ridges are no higher than the bay rims. All these questions are easily answered if we imagine a cake of ice in each bay and tidal waters flowing in and out among these obstructions.

At first, when the tides were deep and strong, the gravel hills were deposited in the larger open areas between bergs. At the same time, channels were eroded out where the bergs were closer together and the current stronger. This kept the gravel hills from approaching too close to the bergs and produced the "kettle holes" or basins around each berg. Big bergs usually produced the dominant current and so the bays formed by little bergs close by seldom overlap the rims of bays made by bigger bergs. There are exceptions to this overlapping of rims, but, in general, the rule holds good. There are, in fact, exceptions to every general feature of uniformity in the Carolina Bays but all of these exceptions can be explained by the varying shape of the bergs, by distance of separation, and by the varying current of water flowing between them. Aerial photographs show this flow pattern around fixed objects so plainly that one wonders why this explanation was not forthcoming long ago.

Another characteristic feature of the Bays is the occurrence of rows or chains of Bays. Many chains of three or more are found nearly touching one another and with stream channels on either side. Usually these chains are made up of bays of nearly equal size and may have resulted from a large berg breaking up after grounding. In any event, such a chain would force the water to flow parallel to the sides of such group and the current would tend to arrange them in better alignment. These chains occur so frequently in the Carolina Bay region that they became a stumbling block to the advocates of the meteoritic theory, for it seemed beyond the realm of chance that meteorites should fall in many rows.

Since the ice probably remained long after the tides receded, the final melting took place without any passing current. Thus the final meltwater overflowed the bowl in which each berg was sitting and produced the delicate sand rims, even improving upon the symmetry that the tidal current had produced. Later, small channels were cut in the rim of each bay, allowing the greater part of each lake to drain into the stream channels.

The Oriented Lakes of Alaska show greatest deviation from the Carolina Bays in that the water drains from one lake to the next. This may be explained by the fact that Alaska was moved from a north temperate climate into the arctic; that the ice bergs stranded there did not melt for many hundreds of years; and that the streams and vegetation built up the land around them so that when the bergs did finally disappear, the streams were forced to flow from one lake to the next.

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The Alaskan Lakes cover an area somewhat larger in size than the Carolina Bays, being about 450 miles east and west and extending from Point Barrow south about 100 miles. As in the Carolina region, the biggest lakes are found near the coast for the largest bergs grounded first. Farther inland the lakes become more scattered, less elongated, and more erratic in orientation. A few scattered lakes of smaller size are also found near the coast, but on higher ridges and plateaus, apparently because smaller bergs were thrown to greater heights by the first great tides and were less well orientated because of the shallower tidal currents following.

In outline, the Alaska Lakes are more rectangular than the Carolina Bays. This was probably due to a different fracture pattern and to the different orientation relative to the sun. The Carolina Bays are oriented in a northwest-southeast direction and therefore the northeast and east side of most bergs received more sunlight and melted faster. This difference in exposure to the sun produced the curious ovoid shape with the straighter side on the shady side. Where bergs were close together so that one might shade the other, the curvature on the shady side fits the theory. Another point bearing this out, is the fact that in large bays with multiple rims, the outer older rim is always a more perfect oval, showing that as the berg melted faster on the sunny side the new formed rims changed in shape with the berg. No other theory has ever been able to account for these multiple rims or the ovoid shape.

In Alaska the lakes are pointed more nearly north and south, the average trend being 12 degrees west of north. Being well above the Arctic Circle (most of them above 70 degrees north) the summer sun shone on all sides of the bergs with little favoritism, so that a more even rectangular shape was achieved.

Another possible reason for the uniformity in outline of these bays and lakes would be that the shock waves from the collision, through the water and through the earth, produced a uniform pattern in cracking the ice. This same collision shock pattern may be seen in the grid-like pattern of the mountains on the moon, especially in the mountain rim around Mare Imbrium. Shock waves traveling outwardly and upwardly might fracture ice floating on a sphere, in boat-shaped forms. In Alaska, which was much more distant from the point of collision than the Atlantic ice, the shock might have cracked the ice in a more rectangular pattern. Such a shattering of ice would almost surely produce a uniformity of some shape but there would be many minor variations. Such is the case, in both Alaska and Carolina, and, as the old proverb goes, "The exception proves the rule."

Conclusion. We believe that the Carolina Bays and the Oriented Lakes of Alaska were formed by strong tidal currents flowing around fixed objects that have since disappeared, that cakes of sea ice are, so

far as we know, the only large objects in nature that could have fulfilled all the requirements, and that cosmic collision flood is the only possible force that could have moved them into place. We therefore rest our case and await the onslaught of our critics.

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Contributions of the Meteoritical Society

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

A Restudy of the Coolac, New South Wales, Australia, Meteorite (ECN = —1481,350)*

EDWARD P. HENDERSON†
Smithsonian Institution, United States National Museum, Washington 25, D. C.

ABSTRACT

A new analysis and a redetermination of the density of the Coolac, New South Wales, Australia, meteorite, which bring this iron into agreement with other meteorites of the same general type, are given. The Coolac meteorite resembles the Canyon Diablo, Arizona, irons. The presence of cohenite was confirmed, and the variation in the internal structure is well shown by the 4 accompanying illustrations (Figs. 1 and 2).

The Coolac meteorite from County Harden, New South Wales, Australia ($\lambda = -148° 7½'$, $\phi = -34° 58'$; subclass = Og), was found in 1874 and was described by T. Hodge-Smith in 1937.[1] The United States National Museum obtained a specimen of this iron thru an exchange with the Kyancutta Museum, Kyancutta, South Australia, in 1940. When the specimen was received, its resemblance to the Canyon Diablo, Arizona, meteorites was one of the first things to be noted; in fact, the Kyancutta Museum was asked whether there was a possibility of a stray Canyon Diablo specimen's having been reported from such a remote locality as a new meteorite, and we were assured that this was not likely to be the case. When the information on meteorites containing cohenite was assembled, it was evident that both the chemical analysis and the specific gravity of the Coolac iron were inconsistent with those of the other meteorites in this group; moreover, since this meteorite resembled the Canyon Diablo irons, it was decided to reinvestigate the Coolac meteorite. Since the Coolac specimen had been cut in 3 directions when it was received, an excellent opportunity existed to see the distribution of the accessory minerals and also the variation in the size of the kamacite on the different surfaces (Figs. 1 and 2).

The details of the discovery and the history of this meteorite are given by T. Hodge-Smith.[1] He reports also the existence of "numerous

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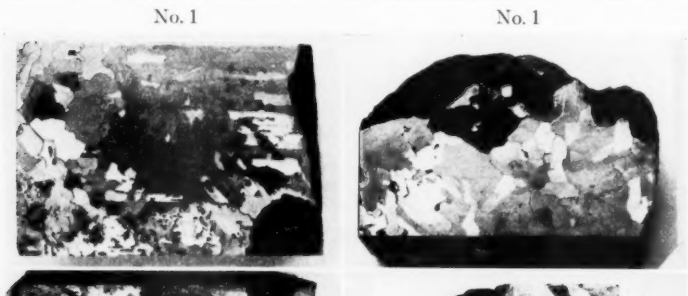

FIG. 1 FIG. 2

THE 4 ETCHED SURFACES OF THE COOLAC METEORITE

Description of the Figures

These 2 figures show the 4 etched surfaces of the Coolac meteorite. The bottom line of No. 1, Fig. 1, corresponds to the top line of No. 2, Fig. 1, and the bottom line of No. 1, Fig. 2, is the same edge as is shown at the top of No. 1, Fig. 1. The right-hand edge of No. 2, Fig. 2, corresponds to the left-hand edge of No. 1, Fig. 1.

These different surfaces show considerable variation in structure. Cohenite is abundant in small, irregular inclusions, and usually contains islands of kamacite. Troilite is present; most of this is surrounded by a thin zone of schreibersite. Very little free carbon is noticeable on these surfaces; in one area, however, where the cohenite is closely spaced, a small amount of a black, carbon-like material occurs. Some plessite is present, but this is not abundant.

The analysis was made of a portion cut from the surface shown in Fig. 2, No. 1, because this area contained fewer inclusions; hence, the results should more closely represent the composition of the groundmass of the meteorite.

The magnification in each of these 4 reproductions is × 5/12.

inclusions which are made up of graphite, iron carbide, and silicate minerals. These three are generally associated with each other, altho the silicates are sometimes found alone surrounded by nickel-iron. The silicate grains are very small and can be seen with the unaided eye only after careful search." Hodge-Smith determined the specific gravity of a portion of this iron weighing half a kilogram and reported it to be 7.15. Such a specific gravity is unusually low for an iron meteorite. The specific gravity was redetermined for the piece used in the re-analysis, which was cut from the face on this specimen that was perhaps at the greatest distance from the natural surface of the iron, and was found

to be 7.849. This value agrees with the densities of other iron meteorites. In the original description of this meteorite, mention was made that it had been used as a fire-stop in an open fireplace for about 4 or 5 years. Perhaps the material for which the low specific gravity was determined had been slightly oxidized by the treatment it had received in the fireplace.

Since this iron had been subjected to many reheatings, a possibility existed that the internal structure may have been slightly modified, at least for a short distance below the surface. Hodge-Smith mentioned that "the etched surface shows that the kamacite and taenite bands have been converted completely to a granular mass."[1] This specimen of the Coolac meteorite does not, however, appear to have undergone any appreciable changes as a result of the heat treatment it received while serving as a fire-stop. The Neumann lines are still preserved in many of the kamacite areas. A close inspection shows numerous Neumann lines in the kamacite within 0.5 cm. of the original surface. If any appreciable structural changes had taken place in this specimen thru reheating, one of the first features likely to disappear would have been the Neumann lines. Some kamacite, however, close to the outside surface of the specimen, shows a limited degree of granulation, but this incipient granulation gradually disappears about 1 cm. below the outside surface of the meteorite. In this specimen, even where the granulation is best shown, careful inspection is required to detect it. Thus the Coolac iron was not adversely affected by its former treatment.

There is a considerable difference between the 2 analyses reported in Table 1, but this may be due in part to the methods followed in selecting the specimens that were analyzed. The original analysis reports 1.27% sulfur, which must have been combined with iron as troilite. This fact means that 3.47% troilite is present; thus, 2.20% of the total iron reported in analysis (1) is combined with sulfur rather than with nickel. The material selected for re-analysis was obtained from a thin slice cut from one face of this sample. An area containing no sizable inclusions and having a structure that was about average for the meteorite was selected.

The 4.72% nickel reported in analysis (1) of Table 1 is definitely low for kamacitic iron and for a meteorite that contains taenite. The 6.78% nickel found in the re-analyzed portion agrees with the nickel content of other coarse octahedrites (Og).

No sulfur was found in the portion re-analyzed, but sulfur is rarely found unless some troilite inclusions are visible in the sample to be analyzed. The repeated failure to find appreciable amounts of sulfur in samples of meteorites that have been selected by the procedure just described indicates that troilite is not soluble in kamacitic iron.

The selected sample from the Coolac meteorite was dissolved in dilute hydrochloric acid (1 part acid to 2 parts water). The residue thus obtained was small, and the magnetic grains resembled a mixture of co-

henite and schreibersite. These magnetic grains were retained in the flask by attaching a small, strong magnet to the bottom. The nonmagnetic portion of the residue was decanted onto a fritted glass crucible and weighed. The magnetic residue was repeatedly washed with dilute acid. Since such a small quantity of nonmagnetic residue was found, it was reported as free carbon and was not further investigated.

No phosphorus was found in the portion soluble in dilute hydrochloric acid. The magnetic material appeared, by visual examination, to be a mixture of cohenite and schreibersite, but, because the quantity was so small, a complete analysis was not attempted. This material, without being weighed, was dissolved in mixed acids, and the nickel and the phosphorus contents were determined because the values of these were considered to be of the greatest importance in this investigation. These 2 determinations are believed to be accurate. Iron was, however, determined for this portion after 5 repeated precipitations by strong ammonia were made, and the final precipitate was dissolved in acid and titrated. A high degree of accuracy is not claimed for the iron determination. Nickel was determined in the combined filtrates from the iron separation after the ammonia salts were expelled.

TABLE 1

CHEMICAL ANALYSES OF THE COOLAC METEORITE

	(1)†	(2)‡ Composite Analysis	Sol. Portion in 1-4 HCl	Ratios	Insol. Magnetic Residue from 1-4 HCl	Ratios
Fe	92.79%	92.31%	7.8090 gm.	0.1398	0.00342 gm.	0.000061
Ni	4.72	6.78	0.5706	0.0097	0.00317	0.000054
Co	0.26	0.87	0.0736	0.0012	n.d.	....
S	1.27	none	none	....	none	....
P	0.06	0.03	none	....	0.00292	0.000094
C (free)	0.01	0.059*	....	....	....	....
C (combined)	0.67	n.d.	....	....	....	....
Silicates	0.33	n.d.	....	....	....	....
	100.11%	100.049%	8.4532 gm.		0.00951 gm.	
Sp. Gr.	7.15	7.849		8.4626 gm., weight recovered		
Mol. Ratio Fe / Ni + Co	19.75	12.82		8.4542 gm., weight of original sample 0.0084 gm., excess		

NOTES TO TABLE 1

*Cohenite is attacked by hydrochloric acid; hence, some of the carbon escaped. Some carbon was possibly freed from this mineral; accordingly, this value has little meaning.

†(1) from T. Hodge-Smith, *Rec. Austr. Mus.*, **20**, No. 2, 1937.

‡(2), E. P. Henderson, analyst.

The octahedral structure is not well developed in the Coolac meteorite, but, where the kamacite bands are best developed, their width is between 2 and 3 mm., and some bands show Neumann lines. Many

large, irregularly shaped kamacite areas exist, which can be seen in Figs. 1 & 2.

Numerous small inclusions of cohenite are located midway of the widths of the kamacite bands. The same kamacite band frequently contains more than one cohenite inclusion. These small cohenite bodies always contain islands of kamacite.

Rounded troilite inclusions are present, the largest found measuring 1.7 cm. in diameter. Most of these inclusions are surrounded by narrow zones of schreibersite, and in a few inclusions there is some carbon enrichment next to the schreibersite. A few small, unidentified inclusions, possibly silicates, were noticed in the area surrounding the troilite inclusions.

Small rhabdites are dispersed thru some of the large areas of kamacite, and a few irregular schreibersite inclusions are present. This meteorite contains very little plessite. Some dark-brown, vein-filling material occurs in the interboundary areas between the coarser kamacite. These veins are very noticeable on the polished faces near the external surface of the meteorite. Some veins penetrate the specimen to a considerable distance (*v.* Figs. 1 & 2).

The chemical composition of the Coolac meteorite does not differ much from those of the Canyon Diablo, Arizona, and Odessa, Texas, irons, yet the agreement is not close enough to indicate that these meteorites are identical. The Coolac iron is classified as a coarse octahedrite (Og). The following table gives some comparative determinations on these 3 meteorites.

TABLE 2

PERCENTAGES OF NICKEL AND COBALT IN THE COOLAC, CANYON DIABLO, AND ODESSA METEORITES

	Ni	Co
Canyon Diablo	7.11%*	0.50%*
Canyon Diablo	7.24*	....
Odessa	7.23*	0.49*
Coolac	6.78	0.87

NOTE TO TABLE 2

*These determinations were made at the University of Chicago and supplied thru informal communications from Dr. Harrison Brown.

REFERENCE

[1] *Rec. Austr. Mus.*, **20**, No. 2, 130-2, 1937.

A Possible Meteorite Crater near Duckwater, Nye County, Nevada (ECN = +1157.387)

JOHN S. RINEHART *and* C. T. ELVEY

Michelson Laboratory, U. S. Naval Ordnance Test Station, Inyokern, China Lake, California

ABSTRACT

A circular crater, known before 1936, near Duckwater, Nye County, Nevada (ECN = + 1157,387), some 225 feet in diameter and from 10 to 15 feet deep,

which may be meteoritic in origin, is described. Altho extensive searches have been made, no meteoritic material has as yet been located in or near this crater.

Mr. J. G. Alverson, a consultant to the U. S. Naval Ordnance Test Station, recently called to our attention the existence of a crater near Duckwater, Nye County, Nevada, that the local residents believe to be of meteoritic origin. We have examined the crater and have talked with several of the people in that area. Altho we found no evidence that conclusively establishes the crater as being meteoritic, we have been unable likewise to ascribe its origin to any other cause. For this reason, it seems advisable to place in the literature a description of the crater and a record of its location.*

The August 5, 1936, issue of *The Tonopah Daily Times Bonanza* carried an article by Mr. C. C. Boak, a veteran amateur mineralogist and professional mining engineer. We quote from that article:

"What I assume to be a huge meteoric crater, 225 feet in diameter, the resting place of a metallic meteor of considerable size, has been located in Railroad Valley, northeastern Nye County, Nevada, and about 120 miles from Tonopah. I am hoping the 'find' will receive the attention it merits by scientists.

"Mr. Ralph Irwin, of Duckwater, had frequently urged me to make a trip with him to what he believed to be a huge meteoric crater. I confess to 100% skepticism, else I could have made the trip years before. I imagined several things it could be rather than a meteoric crater. For instance, I suspected it might be the bowl of a huge extinct thermal spring. Also, there was the possibility of its being a volcanic crater. Likewise, it might be a subsident crater form (caldera), formed by the drawing away of lava from beneath, or [due] to other crustal readjustments. But upon arriving at the crater a few weeks ago, all my preconceived conjectures were speedily swept aside.

"The crater is on a gentle alluvial slope on the eastern side of the Pancake Range. Not the slightest evidence of thermal action or calcareous deposition, or of any run-off channel. Likewise, no visible evidence of volcanic action at, or in the immediate vicinity of, the crater, tho, of course, vulcanism is evident a few miles distant. The theory of a caldera (subsident crater) likewise was discarded, for reason of the perfectly symmetrical and circular shape of the crater and . . . [because] there are no irregularities in its walls to indicate a lateral break or breaks.

"Thus there remains but one deduction—that the crater was formed by the direct fall of a huge meteor."

Regarding the crater itself, Mr. Boak states:

"The only bulge in the rim, and that is but slight, is on the northeast

*The crater is about 4 miles north of U. S. Highway 6 at a point on the highway approximately 10 miles east of the Lock Ranch (ECN = + 1157,387).

side. . . The crater, roughly speaking, is about 225 feet in diameter, and its depth from 10 to 15 feet below the level of its rim."

Further, he relates an old Indian legend:

"A legend which we have every reason to couple with this meteorite crater runs as follows:

"A very old Indian, survivor of a tribe that inhabited this portion of Nevada generations ago, related to Mr. Irwin that his ancestors saw a great ball of fire come rushing from the sky with a loud roar and a light that was blinding. As it struck the Earth, the ground shook and trembled, and for many nights the valley was alight. For a long time afterward the Indians dared not approach the spot where the ball of fire had fallen, lest the 'Fire Spirit' be angered and wreak his wrath upon them. The old Indian who passed this story on has been dead these many years, but Mr. Irwin had remembered it, and when, several years ago, he came upon this crater, he coupled it with the old Indian's tale."

Mr. Boak's description of the crater is substantially correct, except that he fails to mention the fact that the west (uphill) rim of the crater has been eroded away, so that a gully some 75 feet wide terminates in the crater. Run-off thru the gulley has deposited a large amount of sedimentary material in the bottom of the crater. The Irwin brothers, in the early 1920's, dug a shaft in the bottom of the crater in an effort to locate meteoritic material. They found that the sedimentary deposits were at least 25 feet deep.

No meteoritic material has ever been found close to or within the crater, altho extensive searches have been carried out. Mr. Roberts, on whose land the crater lies, and his son have spent "many days" combing the area with World-War-II-type mine-detectors. The Irwin brothers and Mr. Boak have made numerous visual surveys. Mr. Alverson has made at least 2 magnetometer surveys. We, in company with Mr. Harold Turner of the Naval Ordnance Test Station, Mr. Boak, and Mr. Alverson recently spent a day at the site of the crater and examined the area visually and with strong *Alnico* magnets. We likewise located no meteoritic material.

The apparently complete absence of meteoritic material near the crater raises a serious question as to its meteoritic origin. On the other hand, as Mr. Boak pointed out in his 1936 article, it is difficult to see how otherwise the crater could have come into existence. Further study, particularly with regard to structural changes that have occurred in the bedding layers near the crater, might be rewarding.

Oxidite or "Meteoritic Shale," Terrestrialization, and Terrestrialite

FREDERICK C. LEONARD

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ABSTRACT

The term *oxidite* is proposed to replace the synonyms *meteoritic shale* and *iron-shale*. *Terrestrialization* means the terrestrial transformation of a meteorite into something that can no longer be properly regarded as being a meteorite, and *terrestrialite* signifies the product of that transformation. Both oxidite and meteorodes (defined in n. (3) to the paper) are varieties of terrestrialite.

The synonyms *meteoritic shale* and *iron-shale*, which have been applied to the pieces of terrestrially oxidized meteoritic nickel-iron found in such abundance at the Barringer Meteorite Crater of Arizona, at certain other meteorite craters, and elsewhere at the sites of a few sideritic falls, are, and always have been, unfortunate and confusing, simply because the material in question is *not* shale, according to the universally accepted petrographical definition of that term. For this reason, it is proposed that the term *oxidite* be used henceforth to designate "terrestrially oxidized meteoritic nickel-iron." The symbol for this substance, in conformity with the symbolism employed in the simplified classification of meteorites,[1] would consist, in any special case, of the symbol for the particular kind of siderite that has been oxidized, followed by a comma and the lower-case qualified "*o*," which stands for *oxidized* in that classification; *e.g.*, in the case of the oxidite at the Barringer Crater, the appropriate symbol would be "Ogg, o," because Canyon Diablo irons are coarsest octahedrites (Ogg).[2]

A meteorite has been formally defined as a solid body of subplanetary mass that either is in space or has come therefrom, is falling or has fallen as a discrete unit onto the Earth or onto some other astronomical body, and *still retains its essential cosmic character*. The final, italicized part of this definition is quite as important as the parts that precede it, for, if what was once a meteorite has become so terrestrially contaminated as to have lost "its essential cosmic character," it can no longer be properly regarded as being a meteorite, even tho it may still be classifiable as terrestrially transformed meteoritic material, such as oxidite (*cf.* the foregoing paragraph) or one of the so-denominated *meteorodes* recovered from the Brenham Township, Kiowa County, Kansas, Meteorite Crater.[3] The terrestrial transformation of a meteorite into something that can no more correctly be considered a meteorite than can, *e.g.*, the oxide of a chemical element be considered the element itself, may be called *terrestrialization*, and the product of that transformation may be styled *terrestrialite*[4]—a term that is evidently more general, tho not more useful, in its application than is either *oxidite* or *meteorode*, since both oxidite and meteorodes are varieties of terrestrialite.

References and Notes

[1] *C.M.S.*, **4**, 141-6; *P. A.*, **56**, 437-42, 1948.

[2] The so-named *shale balls*, collected at the Barringer Crater, may be called *oxidite balls* or *balls of oxidite*.

[3] *V.* Nininger, H. H., "Notes on Oxidation of Certain Meteorites: The Formation of Meteorodes," *Trans. Kansas Acad. Sci.*, **32**, 63-7, 1929. "The term *meteorodes*, which has been introduced in this paper, may be defined as a nodule of meteor[it]ic origin, consisting of an outer zone of ferrite inclosing the siliceous constituents of the original meteorite" (p. 67, 2nd par.).

[4] Which may be even more succinctly defined as "terrestrialized meteoritic matter."

"Meteoritic Dust" by John Davis Buddhue (Review)

"Meteoritic Dust" by John Davis Buddhue, *University of New Mexico Publications in Meteoritics, No. 2*, The University of New Mexico Press, Albuquerque, 1950; 102 pp., 4 text figs., 8 pls., 17 tables, price $1.50.

Mr. J. D. Buddhue, who is a Fellow of the Meteoritical Society and a Research Associate of the Institute of Meteoritics of the University of New Mexico, has produced a very interesting monograph on the subject of meteoritic dust. It is an up-to-date summary of scientific knowledge in this field; in fact, it is the first comprehensive compilation and correlation of results.

A historical survey of observations of meteoritic dust serves as the introduction. It starts with some doubtful observations made in 1819, and covers data recorded thru 1948. This procedure gives the author an opportunity to review most of the existing literature. He then proceeds to discuss the methods of collecting meteoritic dust. Most of them center around collections from hydrometeors and the use of coated slides or plates on which the dust settles. He stresses the as-yet-not-quite-solved difficulty of separating magnetic particles coming from terrestrial sources from those coming from extraterrestrial sources.

The author assumes that black spherical particles found in the collections are of meteoritic origin and that some irregularly shaped particles containing metal also fall into this class. Some fine microphotographs show these particle types. Chemical analysis indicates the presence of oxides of iron as well as traces of metallic iron and nickel. Future work might consider the use of *X*-ray diffraction analysis for identification purposes.

The particle sizes of the black spheres, from the author's own collections made near Pasadena, California, range between 5 and 80 microns (μ). Of 1975 spheres, 73% fall in the range between 10 and 20 μ, inclusive. This is the size for which the Whipple theory of micrometeorites predicts possible survival in the atmosphere. Thirteen per cent (13%) are smaller than 10 μ, and 12% are between 25 and 40 μ. Only 2% are larger. Except for the smallest particles, the frequency-distribution follows an exponential function. Nininger's (1940) particles of around 90 μ are larger than those found by Buddhue and most other investigators. Murray's "cosmic spherules" found in the

deep-sea oozes by *The Challenger* expedition are even bigger, with diameters of 0.2 to 0.5 mm. This fact casts some doubt upon their appropriate classification as micrometeorites that entered the atmosphere as dust, but does not preclude the possibility that they may be particles that resulted from the explosion of a large meteorite. This point requires further study.

Mr. Buddhue then investigates the question of the total amount of meteoritic matter brought to the Earth's surface. A comparison with previous work shows that various authorities are several orders of magnitude apart in their estimates on this point. Part of the discrepancy is a purely formal one and depends upon whether or not both meteoritic dust and meteorites are included in the estimate. The author expresses his own dust collections in terms of rainfall, and then tries to extrapolate the results on the basis of assumptions about the total annual rainfall over the whole globe. In view of the extreme variability of rainfall, as regards both place and time, this procedure seems to be a rather doubtful one. The best that can be said is that we are dealing with an order of magnitude of 10^7 kg. per year, of meteoritic accretion. This value may be inaccurate by a factor of 10 either way, depending upon the assumptions. Probably nothing less than widespread systematic observations of meteoritic dust will enable us to make even an approximate guess at the right figure.

The question of the origin of the meteoritic dust is most intriguing. Buddhue first reviews the evidence for dust in interstellar space. The existence of obscuring matter there is not to be doubted. Reasoning about the starlight and its polarization leads to the conclusion that the majority of these particles should have diameters between about 1 and 10 μ. Existence of interplanetary dust in our own Solar System also can be taken for granted, with the Zodiacal Light and the Counterglow serving as one piece of evidence. Some of these particles can be assumed to be of quite considerable size, say between 0.1 and 1 mm. in diameter. Some of the collected dust is, of course, of secondary origin; that is, it has resulted from detonating fireballs.

Calculations are given for the terminal velocity and the rate of fall, from Stokes' law, with a series of tables compiled for these rates in relation to altitude, particle diameter, and composition. In the annual variation of particles found at the surface, some relation is noted to known meteoric showers. More observations are suggested by the author to substantiate these findings. Regional variations caused by the Earth's magnetic field also are suspected, but await further evidence.

In an appendix, Buddhue reports dust observations from the Orionid shower of 1947 October 19-20, which yielded at the Pasadena collection point nearly 700 particles with a modal diameter of 10 μ. Another appendix lists 23 oceanic positions where spherules were found in deep-sea sediments. A very valuable bibliography of 108 references concludes the monograph.

All in all, this booklet is a very valuable contribution on which to build further observations and research in this field. Such work is likely to yield interesting data on the Solar System and the Universe, whence come the small dust particles as still cryptic messengers.

H. E. LANDSBERG, *Executive Director,*
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The Planets in May, 1951

By RAYMOND H. WILSON, JR.

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

Sun. The sun will reach a declination of nearly 22 degrees north of the equator by the end of this month.

Moon. The phases of the moon will occur as follows:

New Moon	May 5	8 P.M.
First Quarter	13	11 P.M.
Full Moon	21	12 midnight
Last Quarter	27	2 P.M.

The moon will be nearest to the earth on May 21.

An occultation of ρ Leonis will be visible from the west coast of the United States on May 14, shortly before 11 P.M.

Evening and Morning Stars. Venus and Saturn will adorn the early evening sky; Jupiter, the eastern sky just before dawn.

Mercury. Since Mercury will stand at 25 degrees west of the sun on May 22, it may be seen low in the eastern dawn during the last two weeks of this month.

Venus. This most brilliant planet will continue to increase in brightness and height above the horizon at sundown, so that it will be setting at about 10 P.M. In the telescope its phase will still be gibbous.

Mars. Since it will pass conjunction with the sun on May 22, Mars will be invisible during this month.

Jupiter. Jupiter will be rising by 2 A.M. at the end of the month, and thus will be fairly well situated for observation just before sunrise.

Saturn. Saturn will be near the meridian at dark. The rings will again be almost invisible in a small telescope.

Uranus. Uranus will be moving east-southeastward, midway between μ and ϵ Geminorum. On May 16 the planet Venus will pass 2 degrees north of Uranus.

Neptune. Neptune will be moving northwestward within half a degree to the southwest of θ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
March 3, 1951.

Occultation Predictions for May, 1951

(Taken from the *American Ephemeris*)

The quantities in the columns a and b are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under a for the star to be observed; similarly, with the latitude, using b; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1951	Star	Mag.	Immersion: Greenwich C.T. (h m)	Immersion: a (m)	Immersion: b (m)	Immersion: Angle E from N (°)	Emersion: Greenwich C.T. (h m)	Emersion: a (m)	Emersion: b (m)	Emersion: Angle E from N (°)
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′										
May 1	ϕ Aqar	4.4	9 8.5	−0.7	+1.8	69	10 16.1	−0.9	+2.0	226
15	45 Leon	5.9	4 25.2	0.0	−2.3	154	5 16.0	−0.2	−1.4	269
19	85 Virg	6.2	5 25.0	−1.0	−1.9	152	6 22.5	−1.1	−1.2	263
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
May 3	60 Pisc	6.2	10 40.2	+0.2	+2.5	10	11 21.2	−0.8	+1.1	286
15	45 Leon	5.9	4 35.6	..	..	189	5 4.8	..	..	241
18	ψ Virg	4.9	6 0.8	−1.0	−1.8	141	7 6.3	−0.9	−1.5	282
19	85 Virg	6.2	5 15.2	−0.2	−2.7	182	5 54.0	−2.5	0.0	243
23	CD−28°14268	6.4	9 29.5	..	..	22	10 7.3	..	..	320
Occultations Visible in Longitude +98° 0′, Latitude +31° 0′										
May 1	96 Aqar	5.7	11 53.8	−1.1	+2.0	48	13 10.9	−1.7	+1.7	237
14	8 Leon	5.9	0 48.1	−3.1	−0.2	92	1 59.2	−0.5	−3.2	345
17	31 B.Virg	6.4	2 40.2	−3.0	0.0	92	3 40.6	−0.2	−3.0	356
17	46 B.Virg	6.5	6 56.6	−0.6	−2.2	148	7 55.1	−0.5	−1.3	277
18	ψ Virg	4.9	6 13.9	−0.8	−2.6	165	7 9.1	−1.5	−0.9	263
23	CD−28°14268	6.4	9 8.2	−1.9	+1.3	39	10 7.1	−2.7	−1.7	306
27	42 Aqar	5.6	10 48.5	−1.9	+1.5	59	12 11.4	−1.6	+1.4	225
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
May 1	96 Aqar	5.7	11 49.6	−0.4	+2.4	26	12 45.8	−1.1	+1.3	272
9	354 B.Taur	6.3	2 11.0	−1.1	−1.0	85	3 19.1	−0.1	−1.7	289
15	ρ Leon	3.8	6 57.7	−0.4	−2.1	137	8 0.2	−0.3	−1.6	292
17	31 B.Virg	6.4	1 55.1	−1.3	−0.3	123	3 10.4	−1.3	−1.2	318
17	46 B.Virg	6.5	6 29.9	−0.5	−2.6	169	7 25.4	−1.7	−1.1	266
23	CD−28°14268	6.4	8 28.0	..	..	30	9 5.2	..	..	332
27	42 Aqar	5.6	10 27.8	−1.0	+2.3	30	11 33.8	−1.9	+1.1	268

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

On the evening of 1948 October 14 at 7:00 M.S.T., a very fine fireball was seen over Utah, not only by persons in that state but also by some in Arizona, California, and Nevada. The object appeared after sunset but before it was completely dark at most stations. Also, apparently, over parts of Utah heavy showers were or had just been falling. Due to these unfortunate circumstances only one or two observers used Polaris to aid in the description of the path, and no other star or planet was mentioned. Hence the reports are based obviously upon estimates, most made some days after the event, when the observers had learned that reports were desired, how to make them, and where to send them. Our regional director, Dr. J. Hugh Pruett of Eugene, Oregon, on learning of the fireball promptly put out the usual newspaper publicity, and, due mostly to his efforts, over one hundred reports came in. Long since, Dr. Pruett bundled up the whole batch and sent them to me but press of work prevented my working on them until very recently. Indeed, I am now uncertain whether or not he gave out a preliminary report to the papers, as he frequently does. In any case, all the data have been carefully studied by me, and what follows has no relation to any previous solution, except that on many reports Dr. Pruett made notes which have greatly facilitated my own work.

For some reason, several of the observers were not certain that what they had seen was on October 14, though sure it was near that date. Many others had not consulted their watches and were uncertain of the time, a few even to the nearest hour. Also, a few were in autos and rather nebulous as to their exact location. Some of these complications came from the inevitable delay in getting in touch with, then getting letters from the observers, and in turn sending the proper forms to be filled out. Persons forget details only too easily, and most are untrained in estimating or measuring angles and directions. Dr. Pruett went to great trouble in this case, in some instances writing the same person several times in attempts to clear up uncertainties.

However, the problem of determining the path of the chief fireball discussed in this paper is complicated further by the fact that undoubtedly one or two others of considerable brilliance appeared on October 14 in the early evening. These various fireballs will now be discussed first, to the extent the reports admit. The numbers in parenthesis ( ) from here on will refer to the station on our list.

(4), $\lambda = 118° 24'$ W, $\phi = 33° 28'$ N, J. D. MacInnes (officer on ship), 6:30 P.S.T., $a_1 = 166°$, $h_1 = 23\frac{1}{2}°$, $a_2 = 235°$, $h_2 = 13\frac{1}{2}°$, magn. —2, duration 3.5 sec., train 5 sec. The observer, while quite sure of all the facts given, would not "swear" to the date itself. Apparently this was reported by no one else.

Observations, all of which I am fairly sure refer to one fireball, are reported from: (22), Bend, Oregon; (11), Trona and (23) China Lake, California; and (7) Reno, Nevada. Unfortunately, however, the hour is given only by (7) as "about 7:30 P.D.T." but date uncertain (report was written November 4), and (23) who states "7:30 P.S.T." The observations of (11) and (23), from stations only 20 miles apart, definitely prove that the fireball appeared just east of the 118° longitude circle and fell to the west, at a fairly steep angle. The other two observations, however, do not fit in well enough to make even an approximate solution possible, though the slope of path is confirmed at (22). These notes describe the object: At (7): magn. —5, duration 2-3 sec., train 5-6 sec., white,

no explosion. At (11): magn. > full Moon, duration 5 to 7 sec., red, curved path. At (23): mag. < full Moon, duration 6 sec., yellow-red.

Reports on several bright meteors, with other dates given, were sent in by a few. When these and the quite useless ones, referring to the real object of this paper, were eliminated, there still remained perhaps 60 reports which could be used in one way or another.

The map of Utah in the World Atlas of the Encyclopedia Britannica was used to plot the azimuth lines, as this map is on a large scale and has good projection. A National Geographic Society map of the United States was used for stations outside Utah, and the azimuth lines transferred. While this latter process is not very exact, the errors so introduced are but a small fraction of those inherent in the observations.

It was at once seen that the projected path was in general from S.W. to N.E. The azimuth is better determined than other data as the path was seen as perpendicular to the horizon from (17), 17 miles S.E. of Las Vegas, Nevada, and (20) a point in California whose longitude and latitude were given by an aeroplane pilot as $\lambda = 117° 30'$ W, $\phi = 34° 45'$ N. As these were very distant, they were the more valuable. Station (52), 30 miles east of Beaver, Utah, also reports a perpendicular path, and our adopted projected path passes very near this point. Reports of large angles with the horizon from several stations near and on either side confirm our opinion. The sub-end point is chosen as the approximate center of gravity of azimuth lines from 15 stations. There is a complication here in that what is reported to us is almost surely the explosion point: several observers note fragments going farther or falling. Hence, allowing for the angle of the real path, possible meteorites should be found anywhere from 10 to 20 miles farther north-east of the point which in my opinion we have to choose as the sub-end point. The next step was to calculate the height of the end (explosion) point. For this, there were 17 stations available, with 23 observers. The value derived is 57 ± 20 km. As usual, there is always the suspicion, if not probability, that the estimated altitudes are too great, though I hasten to add that several others which were obvious over-estimates were not included in the 23 actually used. But a close study of the reports would not permit a lower value than what is given.

The determination of the sub-beginning point gave more trouble as most observers did not see the fireball until it had traversed part of its path. However, cross azimuths from 5 stations gave the point chosen, and then altitudes from 8 stations gave 196 ± 42 km. This could be checked by the slope as observed from 5 stations which gave 28°4. As the slope is usually better observed than direct altitudes, the value from this, which is 162 km., was averaged with the 196 km. and the value adopted is 179 km. Again, this may be higher than the truth, but if both ends are too high by approximately the same amount, the radiant point and hence the orbit would be little affected.

When we come to the estimated durations, we find the usual disagreements. There are 51 in all available. Discarding 4 which range from 25 to 60 seconds as impossibly large, the mean of the other 46 is 5.64 ± 3.30 seconds. If the 3 largest (20, 20, 15 seconds, respectively) are omitted, the mean would be 4.73 seconds. This latter value may be preferred by some. The two observed velocities, corresponding to the durations just given are: 41 ± 24 km./sec. and 49 km./sec. However, as little confidence can be placed in a value with so large a mean error, we have as usual assumed parabolic heliocentric velocity in computing the zenith attraction.

As to colors, we are faced with the strong probability that most gave the color at explosion and not that of the object previous to that time. This opinion is borne out by several specific statements. Further, I believe that the cloudy or partly cloudy sky may have tended to redden the object. In any case it seems that there is no doubt that the fireball was red or reddish orange at explosion, while probably it was nearer white or perhaps bluish-green during the earlier part of its flight. There is general agreement that no train was left, and, on the whole, that the object was pear-shaped. The fireball certainly had a disk of apparent size, the better observations giving about ½ to ⅔ the size of the Moon, while on explosion the fireball had a brilliance exceeding that of the full Moon.

With regard to sound phenomena and vibrations we have reports from 7 places, 10 observers. The places were (41) Bicknell, (48) Richfield—4 observers, (52) 30 miles east of Beaver, (57) Antimony, (79) Monroe, (88) Loa, and (99) Toney. Of these (41), (57), (88), and (99) were south of the projected path, the others north of it, the most distant being (48) which is about 50 km. from it. I have calculated the perpendicular distance to the nearest point on the actual path from each, omitting (99), and then the distance from each to the end (explosion) point. In order, the first of these distances run: 88, 105, 109, 112, 106, and 89 km.; to the end point the distances are: 96, 113, 129, 135, 119, and 96 km. At (79) windows were rattled 5 minutes after the body passed. Observers (40) and (84) also at (48) Richfield report rumbling noise; (65) also there reports heavy vibrations. It was "felt" at (41), rattled windows at (79), and at (99) "sound like a blast" was heard. All the 7 stations are near the middle of the path and the phenomena were doubtless caused by the familiar shock wave.

The data, derived from the observations just discussed, are arranged in the usual form in the following table. It will be noted that the orbital plane makes an angle of only 4° with that of the ecliptic and hence that the fireball had direct motion.

TABLE

Date	1948 October 14.58 G.M.T., October 15.08 G.C.T.
Sidereal Time at End Point	302° 29′
Began over	$\lambda = 112°\ 47'$ W, $\phi = 37°\ 48'$ N at 179 ± km.
Ended over	$\lambda = 110°\ 00'$ W, $\phi = 38°\ 53'$ N at 57 ± 20 km.
Length of Path	196 km.
Projected Length of Path	231 km.
Duration	5.64 ± 3.30 seconds (46 Obs.)
Velocity (observed)	41 ± 24 km./sec.
Radiant (uncorrected)	a = 52°, h = 32°
Zenith Correction (parabolic)	—8°.5
Radiant (corrected)	a = 52°, h = 23°.5, $\alpha = 255°$, $\delta = 11°$

The radiant is A.M.S. No. 2321.

The elements of the parabolic orbit are as follows:

$$i = 4°$$
$$\pi = 0°$$
$$\Omega = 201°$$
$$q = 0.96 \text{ A.U.}$$

The west central part of Emory County, Utah, over which the object exploded or broke up, appears on the map to be quite rough and mountainous, with no villages near the sub-end point. Despite the relatively great height of the explosion point—at least as given by our computations—due to the time of day and that some persons definitely mention pieces dropping after the explosion, I

am inclined to believe meteorites fell. While over 28 months have now elapsed, perhaps a search of the area would be justified. At any rate the idea is passed on to persons who may traverse the area.

Lack of space prevents giving the separate observations in detail and a list of the persons who so kindly reported them. To each we desire to express sincere appreciation for their trouble. We believe that their efforts have furnished data on which a fairly good solution is based. Most of all, I wish to thank Dr. Pruett again for the work he did in collecting the reports, without which nothing could have been done. If other parts of the country had equally efficient regional directors, we would have many more paths of fireballs properly solved.

Flower Observatory, University of Pennsylvania, Upper Darby, Pennsylvania.
1951 March 1.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By MARGARET W. MAYALL, Recorder

Spring Meeting of the A.A.V.S.O. The 40th Annual Spring Meeting of the AAVSO will be held May 11-13, 1951, in Washington, D. C., at the kind invitation of the Reverend Francis Heyden, S.J., Director of the Georgetown College Observatory, and the National Capital Astronomers. On Friday evening, May 11, there will be a lecture at the U. S. Naval Observatory by Dr. John S. Hall, on "Effects of Scintillation of Stars." The business meeting, sessions for papers, and the Society dinner, will be held on Saturday. In the evenings and on Sunday there will be an opportunity to visit various observatories and research laboratories.

Nova in Sagittarius. The first nova of 1951 has been discovered in Sagittarius by Sr. Guillermo Haro, Assistant Director of the National Astrophysical Observatory, Tonanzintla, Mexico. He found it on a spectrum plate taken March 7, 1951, in the position: R.A. $17^h\,41^m\,45^s$, Dec. $-20^\circ\,37'\,36''$ (1855), ninth magnitude. The spectrum showed broad emission lines of Hα, Hβ, and Hγ, and had a strong continuum in the red. On March 11, Dr. Thornton Page obtained a spectrum plate at the McDonald Observatory. The nova was tenth magnitude, and the spectrum had very wide emission lines of Helium I, hydrogen alpha, through delta, and 6350, also lines of interstellar sodium.

DK Lacertae (Nova 1950, 22452). Nova Lacertae 1950 was discovered a little over a year ago by Dr. Ch. Bertaud (see these notes for March, 1950), and has been assiduously observed ever since. Its high declination has made it easy to follow throughout the year, and its rapid fluctuations have made it a most interesting object to observe. The nova had no sharp peak at maximum, but has had in general a slow decline from 6th magnitude at discovery to nearly 12th magnitude the first of March, 1951.

The accompanying table gives daily means and the number of estimates of the AAVSO observations. Included in the table are observations by a group of observers in Germany, the Berliner Arbeitsgemeinschaft für Veränderliche Sterne, who are using the telescopes of the Wilhelm-Foerster-Institut and the Archenhold Sternwarte.

DAILY MEANS

224552 NOVA LAC 1950 J.D. 243,3300-3083

	—0—	—1—	—2—	—3—	—4—	—5—	—6—	—7—	—8—	—9—
3300	.....	.....	.....	.....	.....	.....	.....	6.25 4	5.9 1	6.10 11
10	5.92 6	6.06 3	6.00 4	.....	6.68.4	6.82 5	6.70 16	6.81 11	7.18 9	6.82 6
20	7.09 8	7.31 6	6.62 5	7.13 5	7.47 6	7.82 2	7.48 3	7.90 4	7.50 4	7.76 8
30	7.87 11	7.87 15	7.91 7	7.46 4	7.67 3	7.95 9	8.36 7	8.0 1	8.20 7	7.99 9
40	8.21 6	8.42 5	8.47 6	8.4 1	8.30 2	8.42 4	7.90 2	7.69 9	8.18 6	8.35 2
50	8.55 2	8.40 3	8.2 1	7.86 5	8.56 5	8.57 7	8.70 7	8.74 8	0.05 5	9.01 4
60	8.84 5	8.58 2	8.38 2	7.62 5	8.28 3	8.5 1	8.70 2	9.04 4	9.03 6	9.48 2
70	.....	9.03 3	.....	.....	.....	9.7 1	9.14 3	8.8 1	9.07 3	9.35 5
80	.....	.....	8.85 2	9.26 4	.....	9.1 1	9.2 1	.....	.....	7.94 5
90	8.25 4	8.42 2	.....	9.3 1	.....	.....	.....	9.61 5	9.4 1	.....
3400	9.55 2	9.4 1	9.05 2	9.12 3	.....	.....	.....	.....	9.5 1	8.97 3
10	8.34 4	8.64 4	8.90 3	9.30 4	9.41 7	9.35 2	9.65 2	9.53 3	9.53 3	.....
20	9.63 3	9.65 2	9.80 4	9.92 2	9.85 2	.....	9.95 2	9.33 3	9.20 3	.....
30	9.05 2	9.9 1	.....	9.6 1	9.95 2	9.80 3	9.94 4	10.06 4	10.05 7	10.03 5
40	10.30 5	10.1 1	9.87 3	10.11 4	10.14 5	10.14 6	10.2 1	9.95 2	9.8 1	10.5 1
50	9.87 3	10.19 5	9.93 3	10.0 1	9.68 3	9.75 2	.....	9.78 2	10.60 2	10.00 2
60	9.95 2	10.15 2	10.2 1	10.27 3	10.1 1	10.12 5	10.15 3	9.8 1	.....	10.09 5
70	10.45 2	10.33 5	10.35 5	10.1 1	.....	.....	10.10 3	10.30 3	10.38 4	10.17 3
80	10.00 2	10.24 4	8.75 2	8.30 2	8.87 7	9.37 3	9.9 1	10.17 3	10.00 2	9.93 3
90	10.4 1	.....	10.20 2	10.13 3	.....	10.15 2	10.5 1	9.95 2	10.4 1	10.15 4
3500	10.40 3	10.35 2	10.28 6	10.40 3	10.40 2	10.60 3	10.15 2	10.45 2	10.0 1	8.75 4
10	8.78 3	9.50 2	9.83 3	10.05 2	10.00 3	10.03 7	10.15 4	10.20 4	9.95 2	10.1 1
20	10.2 1	10.25 2	10.23 3	10.40 2	10.35 2	10.4 1	10.70 3	10.4 1	10.40 2	10.30 5
30	10.66 5	10.42 4	10.80 2	.....	10.3 1	.....	10.40 3	10.65 2	10.70 5	10.50 3
40	10.5 1	10.64 5	10.67 3	10.95 2	10.60 3	11.0 1	.....	10.25 2	11.10 2	10.65 2
50	10.90 2	.....	.....	10.5 1	10.57 3	10.45 2	10.35 2	10.00 2	9.55 4	9.98 4
60	10.39 8	10.45 2	10.1 1	10.60 2	10.9 1	10.6 1	10.50 3	10.62 4	10.6 1	10.65 2
70	10.54 5	10.60 2	10.75 2	10.6 1	10.53 3	10.60 3	10.70 2	.....	10.7 1	10.7 1
80	10.6 1	10.9 1	11.10 2	10.65 2	10.72 4	11.05 2	11.05 4	10.6 1	.....	.....
90	.....	10.65 2	11.03 3	10.65 2	10.5 1	10.2 1	10.50 2	11.9 1	10.8 1	10.00 2
3600	10.00 2	10.1 1	9.95 2	.....	10.7 1	.....	.....	10.75 2	10.9 1	10.8 1
10	.....	10.80 2	.....	11.0 1	.....	10.8 1	11.0 1	11.0 1	.....	11.7 1
20	11.8 1	10.7 1	11.45 2	.....	11.2 1	.....	.....	.....	.....	11.05 2
30	11.03 3	.....	11.6 1	10.8 1	10.8 1	11.1 1	.....	.....	.....	.....
40	.....	11.2 1	10.0 1	10.52 4	10.52 4	.....	10.80 2	10.35 2	9.7 1	10.30 2
50	10.4 1	10.70 3	11.13 3	.....	10.6 1	11.30 2	11.55 2	11.07 3	11.4 1	.....
60	11.20 3	10.7 1	11.6 1	11.13 3	.....	.....	11.4 1	.....	11.4 1	11.3 1
70	.....	11.8 1	11.3 1	.....	.....	.....	.....	11.30 3	.....	.....
80	.....	.....	11.8 1	11.9 1						

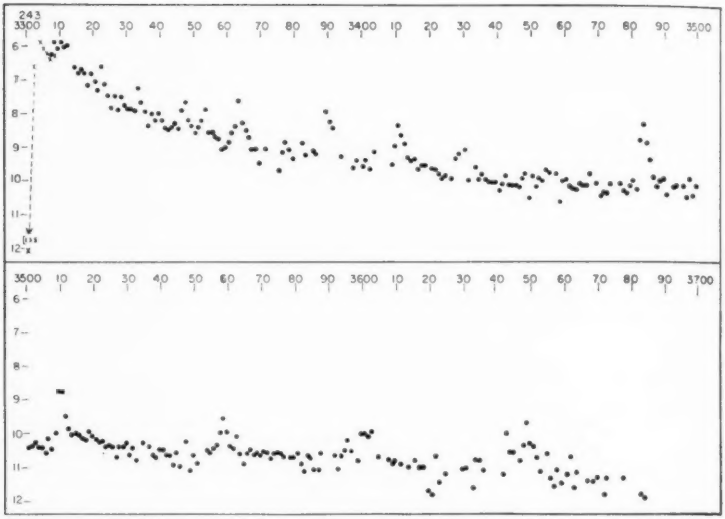

CHART OF MAGNITUDE OBSERVATIONS OF 224552, DK LACERTAE, (NOVA 1950)

Japan Astronomical Study Association. A publication has been received from Mr. Megumi Hara, Secretary of the Variable Star Section, which contains 4,871 observations of 212 stars, made by 27 observers during 1949. The members of the section reported more than 10,000 observations in 1950.

Observations received during February, 1951. Fifty-nine observers contributed 2,974 observations during the month.

Observers	No. Var.	No. Ests.	Observers	No. Var.	No. Ests.
Adams	44	105	Hack	5	10
Ahnert	16	25	Hartmann	155	169
Alfoldi	2	2	Howarth	20	20
Ancarani	12	12	Jager	6	12
Bartha	6	26	Jerabek	5	5
Buckstaff	5	5	Kelly	8	14
Cain	6	6	Knowles	23	23
Charles	11	14	de Kock	100	348
Cobb	5	9	Lacchini	4	4
Costello	11	12	Lankford	6	6
Cragg	125	137	Leutenegger	10	17
Dafter	6	33	LeVaux	123	149
Darsenius	2	3	Lovas	6	15
Diedrich, DeL.	1	1	Mary	65	75
Diedrich, G.	3	4	Meek	31	273
Drakakis	7	10	Melville	11	24
Elias	25	40	Miller	15	15
Escalante	139	246	Morrisby	7	16
Estremadoyro, V. A.	14	21	Motley	19	29
Fernald	100	147	Mount	1	5
Galbraith	37	129	Oravec	38	88
Greenley	87	140	O'Sullivan	13	23

Observers	No. Var.	No. Ests.	Observers	No. Var.	No. Ests.
Parker	27	27	Torok	6	20
Pearcy	10	10	Tury	3	3
Peltier	12	19	Venter	21	21
Penhallow	11	11	Weinstein	5	5
Peter	25	70	Whitehill	2	3
Rosebrugh	18	85	Yamada	32	71
Sinka	6	13	—		—
Taboada	92	112	59 totals		2,974
Tarwater	7	37			

Nova Search. Reports on the Nova Search Program were received during February from the following 15 observers:

Observer	Area	No. Nights	Mag.	Observer	Area	No. Nights	Mag.
	31, 32, 33			Noseworthy, T.	82	7	6
Adams, R. M.	34, 53, 54, 65, 66	6	8	Rick, L.	Dome	2	1
					18, 65	2	4
DeKinder, F.	36	4	6	Rosebrugh,			
Diedrich, DeL.	94	2	5	D. W.	Dome	2	3
Diedrich, G.	Dome	2	2		Dome	1	2
	56	1	6		1, 34	1	4
	56	1	5	Smith, F. W.	3, 4	4	6
	56	1	4	Venter, S. C.	135, 136	3	5
Hall, G.	65	1	6	Williamson,			
Milton, E.	46	3	6	Miss I. K.	79	1	6
Morgan, F. P.	34	2	6	Wright, Mrs. G.	35	4	6
				Jackon, B.	92	2	6

March 15, 1951.

Comet Notes

By G. VAN BIESBROECK

The brightest of the comets visible at the present time PERIODIC COMET ENCKE is now disappearing in the vicinity of the sun. On February 28 I estimated its brightness as $8^{m}6$ while on March 5 it reached $7^{m}1$. A last glimpse was obtained in the twilight at low altitude on March 10 but there were no suitable comparison stars near by. Perihelion occurs March 16 at which time the comet passes rapidly between the sun and the earth. When it emerges in the morning sky in April it will have lost very much in brightness and be best visible for southern observers.

COMET 1951 *a* (PAJDUSAKOVA) is now a circumpolar object best seen in the early part of the night. From 9^{m} on March 5 it had dropped to 10^{m} on March 10. The tail remained well visible and appeared about 8′ long on the latter date. The preliminary orbit given last month (p. 165) needs correction: the ephemeris runs off rather rapidly so that the comet will have been missed by some observers. From now on the brightness is expected to decrease more rapidly.

J. Brady and N. Sherman of the University of California, Berkeley, have computed the following elements for COMET 1951 *b* (AREND-RIGAUX), the second new one discovered this year.

Perihelion passage	1950 Dec. 17.731 U.T.
Node to perihelion	325° 23′
Longitude of Node	124° 37′
Inclination	17° 35′
Eccentricity	0.6327
Mean daily motion	482″.3 (period 7.6 years)

They note that this orbit has some similarity to that of PERIODIC COMET TAYLOR.

In the course of the asteroid survey that Dr. G. Kuiper has organized with the 10-inch Cooke lens at the MacDonald Observatory in Texas the region of the comet had been recorded several times before its discovery. Computing backward with the above elements I located the image of the comet on four plates taken February 4 and two plates taken January 8 by W. Braun, when the magnitude was estimated as 10.5. These prediscovery positions will make it possible to improve the orbit considerably before the object becomes too faint to be easily located. By March 10 the magnitude had dropped to 13 and the coma was hardly noticeable around a nearly stellar nucleus.

PERIODIC COMET PONS-WINNECKE was mentioned last month as having been located on plates taken February 7, 8, and 9 at the MacDonald Observatory. Already February 3, L. Cunningham had recorded the comet with the 60-inch reflector of the Mt. Wilson Observatory. On the same date this observer also obtained a first position of PERIODIC COMET TEMPEL (2) which appeared as a stellar object of magnitude 20 very near the position predicted by T. A. Goodchild (*Handbook B.A.A.*, 1951, p. 45).

Nothing further has been reported about the other faint comets mentioned last month.

Williams Bay, Wisconsin, March 12.

Asteroid Notes

By HUGH S. RICE

There have been no bright minor planets available lately, and at this time, we have only 10th-magnitude planets to offer. 139 JUEWA is found in eastern Hydra; it is at opposition April 27, and of magnitude 10.1 JUEWA was discovered in 1874 by Watson at Peking. 45 EUGENIA is found in eastern Virgo; it is at opposition May 2, and of magnitude 10.2. EUGENIA was discovered in 1857 by Goldschmidt at Paris. 230 ATHAMANTIS is found in western Libra; it is at opposition May 5, and of magnitude 10.6. ATHAMANTIS was discovered in 1882 by de Ball at Bothkamp. 196 PHILOMELA is found in Libra within the quadrilateral; it is at opposition May 14, and of magnitude 10.3. PHILOMELA was discovered in 1879 by Peters at Clinton, N. Y. JUNO, one of the bright asteroids, is to be available for observation in May and June; but it will not be brighter at this apparition than some of the above 10th-magnitude planets.

ASTEROID EPHEMERIDES
0^h U.T. Equinox 1950

139 JUEWA

1951	α h m	δ ° ′
Apr. 14	14 29.2	—25 8
24	14 19.2	—25 17
May 4	14 8.8	—25 10
14	13 59.3	—24 52
24	13 52.0	—24 28
June 3	13 48.2	—24 3

45 EUGENIA

1951	α h m	δ ° ′
Apr. 14	14 49.6	— 6 3
24	14 42.3	— 5 4
May 4	14 34.2	— 4 11
14	14 26.3	— 3 30
24	14 19.6	— 3 8
June 3	14 15.1	— 3 11

230 ATHAMANTIS

1951	α h m	δ ° ′
Apr. 14	15 7.6	—23 0
24	14 59.8	—22 2
May 4	14 50.6	—20 48
14	14 41.2	—19 27
24	14 32.8	—18 4
June 3	14 26.3	—16 48

196 PHILOMELA

1951	α h m	δ ° ′
Apr. 24	15 37.9	—14 57
May 4	15 30.5	—14 43
14	15 22.4	—14 31
24	15 14.3	—14 21
June 3	15 6.8	—14 15
13	15 0.7	—14 15

Hayden Planetarium, American Museum of Natural History,
New York, 1951 March 22.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Shape of the Sikhote-Alinsk Meteoritic Craters in Relation to the "Carolina Bays"

The few persons who still maintain that the elliptical Carolina "Bays" are due to meteoritic impact have been anxiously awaiting authentic reports on the shape of the Sikhote-Alinsk craters. The March, 1950, issue of this Journal should destroy their last hope.

The report of E. L. Krinov, pp. 129-133, describes the craters and illustrates the article with a map.

The map shows that the area of strike of the swarm is a decided ellipse. This indicates that the swarm struck at a fairly low angle. In spite of this, the text indicates that the craters themselves were circular.

It is a well-known fact to Artillery Officers that a projectile which explodes blasts a circular crater regardless of the angle of strike. The same should be true in the case of meteorites. In the case of an incomplete explosion, when an appreciable part of the projectile or meteorite continues into the ground beyond or below the zone of explosion, the direction of strike is indicated by distortion of the surface and, of course, the mass itself if excavation is made.

CHAPMAN GRANT.

2970 Sixth Ave., San Diego 3, California.

General Notes

Dr. Harold Jeffreys, Plumian Professor of Astronomy in the University of Cambridge (England), gave two seminars at the University of California, Los Angeles, the first, on February 19, under the auspices of the Institute of Geophysics, on "The Structure of the Earth," and the second, on February 21, under the auspices of the Department of Mathematics and the Institute of Geophysics, on "The Strength of the Earth."

The Atlanta Astronomers Report, Vol. IV, No. 2, February, 1951, received early in March, has some very interesting features. The front cover shows partly a naked-eye view and partly a telescopic view of the evening sky on February 7, when the moon, Venus, Jupiter, and Mars furnished an unusual spectacle. Also among the titles, the reader's attention is attracted to the following: "It takes Grit to make a Mirror."

German Library for Sale

We have been informed that a large collection of books owned by a German citizen is to be offered for sale because of financial pressure. The collection contains volumes by such well-known authors as Mädler, Goodacre, de la Hire, La Lande, Fauth, Secchi, Flammarion, and others. The list before us contains 69 titles of astronomical classics. Prices are not given, but, doubtless, these volumes may be had for not more than the current price. POPULAR ASTRONOMY will be pleased to put anyone, who is interested in purchasing any of these volumes, in touch with the German source.

Calculating Machines in Europe

Professor Howard H. Aiken, Director of the Harvard Computation Laboratory, reports that nine European countries are actively engaged in the development of "mechanical brains." England, France, the Netherlands, Sweden, and Switzerland have already built large-scale calculating machines, while Belgium, Western Germany, Italy, and Spain are planning construction of their own "mechanical brains"—machines which can solve complex mathematical problems thousands of times faster than the human brain. Professor Aiken estimates that the United States now has about 11 large-scale computers in operation. Several other machines, including Harvard's new Mark IV, are in the building stage.

International cooperation on computing machines is still on an informal basis among individual scientists, Professor Aiken says. UNESCO, however, is considering the establishment of a European computing center. European interest in "mechanical brains," grew after Harvard announced the construction of Mark I in August, 1944. Mark I, designed by Professor Aiken and built by International Business Machines Corporation in cooperation with Harvard, was the first large-scale digital calculating machine.—(*From Harvard University news release.*)

International Astronomical Union News Item

I have just been informed by Professor Strömgren, Secretary General of the I.A.U., that, due to present uncertain political conditions, the Executive Committee of the I.A.U. has decided to cancel the General Assembly in Leningrad and the Stockholm symposia. Professor Strömgren emphasizes the fact that the other activities of the Union will continue without interruption.

The Executive Committee has not yet decided with regard to the time of the next General Assembly.

J. J. Nassau, *Chairman*
U. S. National Committee I.A.U.

Warner and Swasey Observatory, Taylor & Brunswick Road,
East Cleveland 12, Ohio, March 9, 1951.

Provisional Sunspot Numbers for February, 1951*

1	97	10	69	19	36
2	84	11	74	20	41
3	62	12	66	21	44
4	53	13	62	22	51
5	40	14	59	23	55
6	35	15	51	24	61
7	43	16	54	25	67
8	53	17	50	26	72
9	60	18	38	27	80
				28	65

Mean Value for February
R = 57.9

*From the Zürich Observatory, furnished by Mr. Neal J. Heines.

Astronomical League Convention

An annular eclipse and a Zeiss planetarium are two of the special features offered those planning to attend the 1951 Astronomical League Convention, September 1 to 3, at the Morehead Planetarium of the University of North Carolina in Chapel Hill, near the southern edge of the eclipse path. The annual phase will be visible for 38 seconds and occurs ten minutes after sunrise.

The Greensboro Astronomy Club is arranging a social hour for early arrivals August 31, and the regular planetarium demonstration is scheduled that evening. Saturday afternoon will be devoted to eclipse and solar forums, lunar and planetary demonstration, and instrumentation session. The evening will end with a banquet at Carolina Inn. Sunday's highlights will be the exhibits, sessions on observing, and program planning. Monday will bring the final business meeting, regional conferences, Astronomical League Award, and practice observation in the planetarium before adjournment at noon.

A large room has been set aside for exhibits. This year, commercial exhibitors will have an opportunity to show their wares, but, since all space is free, League members will have preferential consideration. There will be no prizes, but lots of ideas to take home.

Persons attending the convention will be accommodated in dormitories on the University campus at a cost of $2.75 per night for a single reservation, $4.00 for a double. A cafeteria, hotel dining room, and several restaurants are within four blocks of the planetarium.

Several societies are cooperating with the Convention Chairman to make this a memorable affair. Richard C. Davis and the Raleigh astronomers are primed on

train, plane, and bus schedules to Chapel Hill. T. W. Stone and others from Richmond are bent on making the exhibit equal to the eclipse itself. P. N. Anderson and Elizabeth Frazekas, Norfolk, Virginia, and members of the Washington society are assisting.

G. R. WRIGHT, *Convention Chairman*

The Cleveland Astronomical Society

Dr. Harlow Shapley of the Harvard College Observatory addressed the March 9th meeting of the Cleveland Astronomical Society. His subject was "The Magellanic Clouds."

Dr. Shapley first described briefly the various types of nebulae, illustrating them with lantern slides. He then showed how the extragalactic nebulae have been arranged in a sequence from the spherical forms through the elliptical systems and then branching into normal spirals and barred spirals. He suggested that the evolution might have progressed from the spiral to the spherical form.

The speaker soon led the audience to the Magellanic Clouds, one of his many areas of research. These clouds he described as the nearest of all extragalactic systems, the Large Cloud being some 81,000 light-years away and the Small Cloud some 10,000 light-years farther out. They lack the rotational symmetry characteristic of the elliptical and spiral systems and are classed as irregular systems.

The position of the Magellanic Clouds, well away from the plane of the Milky Way and its interfering dust clouds, and their close proximity to our own galaxy make them very favorable objects of research. Dr. Shapley called them the tool-house of astronomers because they contain such a variety of objects in favorable positions and also present a variety of problems.

The Magellanic Clouds, the speaker said, contain the largest and the brightest stars yet known. S. Doradus, in the Large Cloud, is the most luminous star known, having an absolute magnitude of —8.9 or a luminosity 600,000 times that of the sun. This cloud also contains the gaseous nebula 30 Doradus of absolute magnitude —10, the most luminous object of its class. These clouds are vast aggregations of stars but also contain many open clusters, globular clusters, Cepheid variables, and gaseous and diffuse nebulae. It was in the Small Cloud that the period-luminosity relationship of Cepheid variables was worked out at the Harvard College Observatory.

Besides giving the Society a very interesting lecture and letting them in on some of the hottest (up-to-the-minute) research in astronomy, Dr. Shapley kept the audience in stitches with his wit and humor.

HENRY F. DONNER, *Recording Secretary*

Western Reserve University, Cleveland 6, Ohio.

Book Reviews

Fundamental Constants of Astronomy. (Centre National de la Recherche Scientifique 13, Quai Anatole-France, Paris 7e.)

This paper-bound pamphlet of 130 pages contains a report of an international committee formed for the purpose of standardizing the generally-used astronomical constants. The committee was convened by M. Danjon, director of the Paris Observatory, in Paris from March 27 to April 1, 1950. The personnel of the committee was as follows: Kopff, from Germany; Brouwer, Clemence, H. R. Mor-

gan, from the United States; Chazy, Danjon, Esclangon, Fayet, Mineur, Stoyko, from France; Jeffreys, Sadler, Harold Spencer Jones, from England; Oort, from the Netherlands; Ambartsumian, Batrouchevitch, Kulikov, Nemiro, Zverev, from the U.S.S.R.

The several parts of the pamphlet consist of (1) the preliminary reports presented by nine of the persons present, (2) the address given by Sir Harold Spencer Jones at the opening session, (3) the minutes of the several sessions, taken by Sadler and translated by Fayet, (4) recommendations formulated at the closing session, to be submitted for approval to the International Astronomical Union. C.H.G.

The Analytical Balance Its Care and Use, by William Marshall MacNevin, Professor of Analytical Chemistry, The Department of Chemistry, The Ohio State University, Columbus, Ohio. (Handbook Publishers, Sandusky 6, Ohio. 1951 xiii + 60 pp. 20.3 × 13.7 cm. $1.50.)

The preface states, "It provides practical information about the care and use of the modern analytical balance. It is designed to acquaint the average scientific worker with the problems of selecting, mounting, cleaning, adjusting, testing and repairing a balance. It is also designed for the technical worker who has had little or no training in the use of the balance. A section on 'How To Use The Balance' is therefore included. One feature of this monograph is a list of names and addresses of balance manufacturers. It is hoped this may be useful to those who contemplate the purchase of balances. A similar feature is a list of names and addresses of individuals and small companies who are balance repair specialists. It makes the point that the average scientific worker should not attempt to make major repairs but should call upon a specialist to do this for him. It does, however, suggest how to determine when repairs are necessary. For the more advanced scientific worker it is hoped that the section on testing the balance for performance characteristics will aid him in obtaining improved performance from his balance. No attempt is made to discuss the theory of the balance since this is adequately described in several places to which reference is made." The book also discusses analytical weights and their calibration by the usual methods. The adjustment of weights, and correction of weighings to vacuo are presented. Micro balances are not considered. The book is clearly written, and has a good index, in which the reviewer detected only one very minor error. It is attractive and well bound—good paper, typography, layout, printing, and binding. To the reviewer's knowledge it is the only up-to-date book on the subject in English. It meets a real need; and it will be appreciated by all who use a balance.

C. Sheldon Hart,

Carleton College.

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